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PALM AND SOLE IMPRESSIONS AND THEIR USE FOR PURPOSES OF PERSONAL IDENTIFICATION.

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IN a former number of this magazine (November, 1902) I gave a brief account of the epidermic ridges upon the human palmar and plantar surfaces, and emphasized their great individual difference and their applicability for use in the identification of individuals, living or dead. In the present article I shall endeavor to set forth a simple method by means of which these individual records may be formulated and classified and thus be rendered serviceable as a practical system of personal identification.

Aside from the use of photographs and the more obvious descriptive methods, which include such attributes as height, weight, color of eyes and hair, moles, birth and tattoo marks, etc., there are now in use two distinct scientific systems of identification, that of M. Alphonse Bertillon, based upon bodily measurements, and that of Mr. Francis Galton, based upon the epidermic ridges of the finger tips.

These two systems are absolutely distinct from one another, although, judging from frequent newspaper notices, they are popularly confused, with a tendency to ascribe both to Bertillon, in the same way that electrical inventions are popularly associated with the name of Edison, or theories of evolution with that of Darwin. Indeed, there seems to be a common disposition in America to ascribe the idea of the use of 'thumb-marks' to Mark Twain, who in his 'Puddenhead Wilson' has undoubtedly done much to call the public attention to the epidermic ridges of that very restricted area, although, as a consequence of the story, one continually meets with the notion that the epidermic pattern

of the ball of the thumb (usually considered to be the right one alone) is individual and distinctive, while those of the remaining fingers, or the similar markings of the palm are of no importance.

It is of interest also to note that, owing to the common belief in palmistry, whereby divination is performed by means of the chance wrinkles caused by the motion of the fingers, these useless features have assumed so great importance that the far more interesting ridges appear to be usually ignored or even overlooked entirely, and as for the ridges of the sole of the foot or the balls of the toes, their very existence appears to be generally unknown.

Since there seems to be so much popular misinformation upon the subject of systems of identification, it may not be superfluous to begin the present discussion with a brief description of each of the two systems mentioned above, after which will be presented the claims of the system based upon palms and soles.

I. *The Bertillon system.*

The first scientific method for classifying humanity by data furnished by individual bodily peculiarities, or at least the first that became widely adopted, was that devised by M. Alphonse Bertillon, who in 1880 founded his celebrated system of identification by means of bodily measurements, 'Identification anthropométrique.' In this he applies the principles of anthropometrics, employed hitherto mainly as ethnological criteria or for use in physical culture, to the identification of individuals, using for that purpose only those measurements which depend on skeletal parts, and which are, therefore, practically unchanging after adult life is reached. The measurements selected to form the basis of his system are as follows:

I. Measurements based upon the entire body. [*Mesures relevées sur l'ensemble du corps.*]
  Standing height. [*Taille—hauteur de l'homme debout.*]
  Arm reach. [*Envergure des bras.*]
  Sitting height. [*Buste—Hauteur de l'homme assis.*]
II. Measurements based upon the head. [*Mesures relevées sur la tête.*]
  Length of head. [*Longueur da la tête.*]
  Breadth of head. [*Largueur de la tête.*]
  Length of right ear. [*Longueur de l'orcille droite.*]
  Breadth of right ear. [*Largueur de l'oreille droite.*]
III. Measurements based upon the extremities. [*Mesures relevées sur les membres.*]
  Length of left foot. [*Longueur du pied gauche.*]
  Length of left middle finger. [*Longueur du doigt médius gauche.*]
  Length of left little finger. [*Longueur de l'auriculaire gauche.*]
  Length of left cubitus. [*Longueur de la coudée gauche.*]
    i. e., elbow to tip of extended middle finger.

Each of these eleven measurements is subdivided into three groups, small, medium and large [*petit, moyen, grand*]; in accordance with

definite though arbitrary limits, themselves the result of much experience in measurements, and designed to divide any average set of measurements into three approximately equal divisions, rather than to divide equally the range of millimeters between the extremes of a given measurement. Thus, to quote an example furnished, "the numerical limits of the 'medium' head-length as used at the Prefecture of Police in Paris include an interval of but 6 millimeters (185–190), while those included under 'large' extend from 191 mm. to the greatest dimensions possible, an extent of more than three centimeters."*

Now if we were to conceive of each one of these eleven measurements as varying independently of one another and as being divided into three subdivisions, the number of possible subdivisions under which individual anthropometric records could be filed would reach the large number of 3 to the 11th power, or 177,147, but in practical use M. Bertillon employs for purposes of identification only a few of these measurements, which he gives in the work just quoted, together with an hypothetical application, as follows:

He supposes the case of 90,000 sets of measurements, a number approximately corresponding to that of the adult male prisoners recorded in the Paris prisons up to 1893. Of these the first classification is made by means of the *length of head,* and as the subdivisions, small, medium and large, are fixed with reference to equality of division, approximately 30,000 of these records will be placed in each.

Each of these subdivisions is now divided again into three parts, in accordance with the *breadth of head,* a division which leaves approximately 10,000 in each of the nine compartments, *i. e.,* 10,000 individuals whose head length and head breadth fall into the same categories. The third division, which reduces the number of records in each of 27 compartments to about 3,300, is based upon the *length of the left middle finger,* and the fourth, resulting in 1,100 in each of the 81 compartments, is based upon the *length of the left foot.* The *length of the cubitus* then follows, which increases the number of compartments to 243 ($=3^5$) and the number of individual cases in a compartment to less than 400. By the addition of the *standing height,* the number of compartments is increased to 729 ($=3^6$) and that of the cases in each compartment to approximately 130, and these numbers become respectively 2187 ($=3^7$) and 42 by the use of measurements taken from the *left little finger.* These are finally reduced to small sets of a dozen records each by such criteria as the *color of the eye* and the *length of the right ear,* after which this small number may be carefully compared for individual measurements.

With some modifications the above system is in official use in most of the civilized countries of the world, including England, Russia,

* Bertillon, A. 'Instructions Signalétiques,' 1893. Introduction.

Belgium, Switzerland, the United States and the majority of the South American republics, but in at least some of these cases the governmental acceptance of the system does not mean an extensive practical use, a condition of affairs especially true in the United States, where the governmental acceptance means merely an official sanction and where each state, or even each municipality, may employ its own methods of recording and registering criminals, quite independently of its neighbors. In this country the main reliance is placed upon photographs and descriptions, sent to various police headquarters in the form of little handbills, and although one sees occasionally among the descriptive part of these a set of Bertillon measurements (without further designations), it is very doubtful if in cities of moderate size the police authorities have any definite idea of their significance, or possess the necessary instruments for obtaining these measurements and thus verifying the data furnished. In England the Bertillon system is extensively employed, although in a somewhat modified form, to which is appended, at present as a supplementary system, that of Galton, to be described below. On October 21, 1893, a departmental committee was appointed by the home secretary, the Hon. H. H. Asquith, to inquire into the various methods of identification of criminals, and an official report was presented by them on February 12, 1894, and published as a Bluebook (C. 7263). The recommendations embodied in this report, and adopted in full by the English government, were as follows (paraphrased):

I. To photograph criminals as at present, the photographs to consist of both a front and profile view, taken on separate negatives, and not by means of a mirror, as heretofore.

II. To employ the first five of the Bertillon measurements, as follows, expressed in millimeters:

1. Length of head.
2. Breadth of head.
3. Length of left middle finger.
4. Length of left forearm.
5. Length of left foot.

III. To take the finger prints by Mr. Galton's method.

IV. To add a brief description including the height in feet and inches, color of hair, eyes and complexion and distinctive marks, the latter in a fixed order, beginning with the head, then the hands and arms, then the body, and lastly the legs and feet.

With regard to that portion of the recommendation which concerns the Bertillon system the committee gave its unqualified approval to the use of the first five categories as given above, but felt that the further subdivisions (height, length of little finger and color of eyes) were rather unsatisfactory. As stated in the report:

The length of the little finger is closely correlated with the length of the middle finger; in most cases where the one is long, the other is long also. The height again is a very unsatisfactory measurement; it is subject to varia-

tion in the same person, and it may be attended by trickery on the part of the person measured. By the Metropolitan Police a margin for error of two inches in each direction is allowed in classifying cases by height. Even with the greater accuracy of the French measurement a considerable margin has to be given. The accurate description of the color of the eye is still more difficult. The seven colors taken by M. Bertillon can be discriminated only by persons having much practical experience, and even then many doubtful and transitional cases must occur.

For the 'primary classification,' that based on the first five Bertillon measurements, a complete outfit, such as would be necessary at an important registration station, would consist of 243 drawers, corresponding to the 5th power of 3, the number of possibilities involved.

The arrangement of this index register will be the same as M. Bertillon's, a cabinet of drawers first divided vertically into three divisions according to length of head, and horizontally according to width of head. The nine sections thus formed will be divided vertically according to length of finger and horizontally according to length of forearm, and again vertically according to length of foot. There will be 243 drawers, each containing one class of cards. The figures which are to determine the 'long,' 'medium' and 'short' of the several classes might be borrowed in the first instance from M. Bertillon, but in that case on account of racial differences they would have ultimately to be altered in order to keep the classes equal in size. It would be best, therefore, that the measurements taken in this country by Mr. Galton and by the Anthropological Institute should be utilized and correct figures for England fixed from the outset.

The above quotation from the English report is given in full mainly for the purpose of showing the great disadvantage to the entire system, which results from racial differences in bodily proportions, a fact which will necessitate either one of two alternatives, both bad; that of using special figures for each country or of having very unequal subdivisions in certain cases. This is a decided barrier to the internationalizing of the system and must necessarily be reckoned as a serious defect.

Without meaning to seem ungracious to a system the advantage of which over all previous methods has been universally recognized, and one the scientific principles of which reflect so much credit upon the deviser, it may be well, in closing this brief account, to enumerate the defects of the Bertillon system, some of which are, indeed, incident to any system which human ingenuity can devise, and the most of which have been foreseen, acknowledged and corrected so far as possible by M. Bertillon himself.

1. The limitation of the system to the period of adult life.

2. The necessary disparities between the same measurements taken at different times by different mensurators, or indeed by the same one (percentage of error).

3. For the purpose of an equal classification, the necessity of assigning independent limits to the records kept by each nation.

4. The greater amount of time consumed in making a set of meas-

urements and in recording and classifying the same, as compared with the printing and reading required by either the Galton system or by the one advocated in the present paper. A careful test of this has not yet been made, but when we consider the number of single acts involved in the making of the records required by each system, the conclusion is obvious. In identifying an individual by means of a previous record, the Bertillon system demands a complete remeasurement, while by the palm and sole system a mere glance at a single palm is often sufficient to establish the identity or the reverse. Ordinarily the difference of time may not be great, but in the stress of modern competition a slight disadvantage in this particular may be regarded as a relative defect.

5. A more serious defect, which is also brought out by comparison, is that the certainty of a Bertillon determination is not absolute, while that of a system which involves either the finger tips or any other considerable portion of the epidermic ridges of hand or foot is beyond question. This has been thoroughly proved statistically by Galton and morphologically and embryologically by a series of recent investigations in my laboratory.* The proof afforded by the study of duplicate or 'identical' twins, where the resemblance, though greater than it can be in any other two persons, is still not absolute, affords farther evidence of the same.† Galton says that a proved identity of finger prints "far transcends in trustworthiness any other evidence from any number of ordinary anthropometric data. *By itself it is amply sufficient to convict.* Bertillonage (*i. e.*, the system of Bertillon) can rarely supply more than grounds for very strong suspicion; the method of finger prints affords certainty."‡

Although in the original system devised by him Bertillon confined his attention mainly to anthropometric measurements and rejected all use of epidermic marking of hand or foot as impracticable§ in his capacity as chief of the Bureau of Identification and with the evident

* A report of these investigations will shortly be published. See note, p. 396.

† See *Am. Journal of Anat.*, Vol. 1, No. 4, November, 1902.

‡ 'Finger Prints,' Macmillan, 1892, pp. 167–168.

§ "Ainsi la solution du problème de l'identification judiciaire consistait moins dans la recherche de nouveaux éléments caracteristiques de l'individualité que dans la decouverte d'un moyen de classification. Certes, je ne conteste pas, pour ne parler que du procédé chinois, que les arabesques filigranées que presente l'epiderme de la face anterieure du pouce ne soient à la fois fixes chez le même sujet et extraordinairement variables d'un sujet à un autre; et que chaque individu ne possède là une espèce de sceau original et bien personnel. Malheureusement il est tout aussi indéniable, malgré les recherches ingenieuses poursuivies par M. Francis Galton, en Angleterre, que ces dessins ne presentent pas par eux-même des éléments de variabilité assez tranchés pour servir de base à un repertoire de plusieurs centaines de mille cas." Bertillon. 'Instructions Signalétiques,' 1893, Introduction.

desire of bringing his work to the highest degree of efficiency, he has recently adopted a part of Galton's system, and places the impressions of certain of the finger-tips upon his identification-cards.

Unfortunately, I can not ascertain the exact date at which this adoption of Galton's system was made, but upon a fac-simile card, shown in a recent popular article on Bertillon's system (*Leslie's Weekly,* April 16, 1903), which is dated August, 1901, spaces appear below the words 'Pouce, Index, Medius, Annulaire' and are plainly intended for the reception of the corresponding finger-prints. Within a few weeks of the present writing there have appeared in various newspapers (*e. g., Boston Herald*) accounts of the employment in the State Prison at Auburn, N. Y., of imprints both of the fingers and of the entire palm, but I am unable to ascertain anything definite concerning the manner in which these prints are to be used. Mr. John N. Ross, the chief of the Bertillon department of the above-named prison, has kindly given me what information he can concerning the matter, but writes that it is 'an entirely new departure' and that 'directions as to its application have not yet been received by the Bertillon operators of the different penal institutions' (June 29, 1903). I am thus unable to say whether M. Bertillon has in mind the incorporation of any part of my system with those of himself and Mr. Galton, but I have furnished him with reprints of my two previous papers on the subject and have sent him also numerous manuscript notes and sample prints, which together present the essential points of the system as given in this paper.*

Should this system of mine be found of value and permanently incorporated with the others, the 'Bertillon' system known in actual practice will be, like most other inventions of real value, a composite resulting from the independent investigations of several individuals working from different standpoints, and should be carefully distinguished from the real Bertillon system as described by him in his published work, and outlined above.

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* M. Bertillon's reply to the sending of my first paper is as follows:

PARIS, le 12 Janvier 1903.

MONSIEUR.

J'ai pris grand interêt à la lecture de votre étude sur les lignes papillaires du pied et de la main, et je vous prie de recevoir tous mes remerciments pour l'obligeance que vous avez eue à m'adresser cette publication.

Conformement à votre désir, je vous transmets un examplaire de l'Introduction de l'ouvrage qui j'ai fait parâitre en 1893 sous le titre de " Instructions Signalêtiques." l'editeur en est Mon. Durand, Rue Oberkampf No. 80 à Paris.

Veuillez agrier, Monsieur, l'expression de mes sentiments les plus distingués.

Le Chef du Service de l'Identification

A. BERTILLON.

Monsieur H. Wilder à Northampton.

II. *The Galton system.*

In the popular mind, as attested by numerous works of fiction and by newspaper articles, the main use of the patterns of the finger tips is to aid a detective in identifying a criminal by means of the marks which his fingers have left upon the objects which he had handled; but, as a matter of fact, although such a proceeding is certainly possible, Galton seems never to have suggested such sensational aid to detective work. Both the Bertillon and the Galton systems are rather methods of describing and registering a man, whether a criminal or not, by certain physical peculiarities and in such a way that he or his body may be identified at any future time; and both involve two procedures, (1) that of taking certain individual records, and (2) that of classifying and arranging them so that they may be easily found when occasion requires. The Galton system is based upon imprints of the epidermic patterns found upon the balls of the thumbs and fingers, and Mr. Galton, although by no means the first to employ such means for the identification of individuals, is the first to attempt a careful and scientific system by which these data may be described, registered and classified.

The use of such prints has been sporadically employed in both ancient and modern times, and seems to have long been in use among the Chinese, but data concerning the official workings of this vast and ancient empire are difficult of access to Europeans, and it is likely, as in so many other claims, that the facts when found will be disappointing when compared with the reports concerning them. Galton himself was first led to the study of finger prints by his friend Sir William Herschel* who, when 'Collector' or chief administrator of the Hooghly district in Bengal, added to the signatures of the natives upon all official documents the imprint of the index and middle fingers of their right hands, taken by means of the ink employed for his office stamp.

Galton, indeed, says of his friend that 'if the use of finger prints ever becomes of genuine importance, Sir William Herschel must be regarded as the first who devised a feasible method for regular use and afterwards officially adopted it,' but it must also be remembered by the one who writes the final history of this system that it was Galton who devised the method by which such prints could be described and classified, and thus become of practical value.

The Galton system of personal identification by means of finger prints rests upon two necessary principles, both of which have been established by him beyond refutation:—

I. The absolutely individual character of the markings.

II. Their permanence throughout life.

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* In Indian Service 1853–1878.

The records employed are the printed impressions of the ten digits placed in a definite order upon a card, and the separate cards are placed on file by means of a classification wholly dependent upon the individual patterns.

Of those latter there are three types, the *arch,* the *loop* and the *whorl,* designated in descriptive formulæ by their initial letters, A, L and W (hence the name of 'the *alw* system' by which Galton has designated it). Of these the loop, which may turn to either the radial or the ulnar side of the hand, is for some purposes farther subdivided into *radial* and *ulnar* loops designated respectively as R and U. The patterns are definite in their nature; transitions between them are of rare occurrence and these are nearly always referable to one type or the other. This system of 'ALW,' with the occasional subdivisions of the R and U, forms what Galton designates the '*Primary Classification,*' and the finger tip records of any number of individuals are arranged in accordance with a preconceived order. Although he has made several experiments in this, in his final method (1895) the sets are first arranged in four divisions (ARUW) in accordance with the type of pattern found upon the *right index finger.* This is followed by (small) letters designating the patterns upon the middle and ring fingers of the same hand, using l instead of r and u for all looped patterns. This will be seen to subdivide each of the first four divisions into 9 or will divide an entire set into 36, as follows:

Aaa	Raa	Uaa	Waa
Aal	Ral	Ual	Wal
Aaw	Raw	Uaw	Waw
Ala	Rla	Ula	Wla
All	Rll	Ull	Wll
Alw	Rlw	Ulw	Wlw
Awa	Rwa	Uwa	Wwa
Awl	Rwl	Uwl	Wwl
Aww	Rww	Uww	Www

If, now, the prints in each of these 36 divisions be farther subdivided in accordance with the same three fingers of the left hand, each subdivision consisting likewise of 36 compartments, the entire collection will be divided into 36^2 or 1,296. The thumb and little finger of the right hand which show 9 possible combinations, will subdivide each of the 1,296 compartments and, in like manner, the patterns of the thumb and little finger of the left hand will give another subdivision of 9, so that the number of possible compartments or subdivisions into which a set of prints may be arranged by means of this primary classification alone is $1,296 \times 9 \times 9$ or 104,976; and since the various combinations with a few exceptions occur with about the same frequency, the number of separate prints in a collection of five

hundred thousand which it would be necessary to look over carefully in comparing with a certain definite case would average about five.

The data necessary for this latter comparison are abundantly furnished by the details of the individual ridges, termed by Galton the 'minutiæ,' and the farther description and subdivision of the records by means of these he terms the '*Secondary classification.*' These and other useful details are appended to the formulæ given above by means of 'descriptive suffixes,' arbitrarily selected and described in a table, a copy of which must, of course, be always at hand, at least until it be thoroughly committed to memory by the clerk in charge of the records. The nature of these suffixes and of the details which they describe may be learned from the following examples, taken at random from Galton's table:

g. The core to the whorl is very large.
o. The core of the whorl is a detached ring.
x. Interpretation questionable; the pattern is peculiar.
† Scar left by a cut.

The implied suggestion of 'x' brings up a question which probably occurs to the reader at about this time, namely, whether a pattern is ever of a mixed type, or half way between two, thus giving a chance for a difference of interpretation and a consequent embarassment in finding the case from the formula. This certainly occurs occasionally, but Galton has well disposed of the difficulty by comparing it to the doubt experienced when consulting a city directory for a Scotch name beginning with 'Mac,' variously written, either in full or as Mc or M', and classed differently by various lexicographers. In both cases the investigator, failing to find what he desires in one place, looks in another, and neither here nor there is the difficulty a serious one.

Each finger tip record is placed on a card measuring 12 x 5 inches, and contains, when complete, rolled impressions of the ten digits, a set of 'dab' impressions of the four fingers of each hand (as duplicates for comparison) and, at the right hand upper corner, the formula. In Scotland Yard a folded paper is used instead of a card, and the arrangement of the prints differs somewhat from the above.

Concerning the practical adoption of the Galton system at present, it is hard to get details, but the recommendation of the English committee in 1894 has been referred to, and it seems that since that time the method has come into quite general use in England. It is of course impossible to devise a method which in every detail will be perfect from the start, and as Mr. Galton is continually at work upon his system, the improvements suggested both by him and by those practically engaged in the work can not fail to modify details until it is brought to the highest degree of efficiency.

III. *The palm and sole system.*

The method which it is the purpose of this paper to advocate and briefly explain is closely allied to that of Mr. Galton and is, in fact, *an extension of his system to the palmar and plantar surfaces, which are covered with the same sort of ridges as are the finger tips and in which the variation is greater and the details larger and more obvious.* A moment's inspection of a human hand and foot will show that the entire ventral surface of each, including that of the digits, is covered by a peculiar sort of skin, very different from that found elsewhere, and that along the sides of the palm and the digits, and just above the sole upon the foot, there are definite lines of separation between them and the normal skin, which in the hand corresponds in general position to the seam in a glove which unites the upper and under surfaces. This palmar and plantar skin differs from that of the rest of the body in many ways. It is absolutely hairless and at no time during embryonic life shows indication of either hairs or hair follicles. It consequently has no power of forming goose-flesh when chilled, although the back of the hand and the surface of the forearm, in the immediate vicinity of the palm, are favorite places for the display of this phenomenon. It is also very slightly, or not at all, pigmented as is readily seen by inspection of the palms and soles of a negro, and consequently does not tan or freckle, a distinction often made very obvious by a comparison of the back of the hand with the palm. The most obvious character, however, and the one which directly concerns both Galton's system and the one advocated here, is that of the small but distinct epidermic ridges, which cover the surfaces in question. These may be said to run in a general way parallel to one another and diagonally across the palm or sole, although in certain regions their direction is altered and at more or less definite places they form curiously disposed patterns, usually in the form of loops or spirals. With a moderate lens these ridges give the skin an appearance much like that of corduroy and there may be seen running along the middle of each ridge a row of minute indentations or pores, at about equal distance from one another, the orifices of the perspiratory glands. Running over and across these ridges in directions which bear no relation to them are the wrinkles or *rugæ,* more abundant in the hand than in the foot, and caused by the various motions of the digits and of the other movable parts of the member. Those seem at first especially obvious and interfere more or less with the study of the ridges, but a little practice will enable one to ignore them altogether. In printed impressions, which are used for purpose of study far more than are the actual surfaces, most of these are pressed out of existence while the remainder appear merely as narrow white streaks which do not affect the investigation (see Figs. 1 and 2).

These ridges and their peculiar disposal are an inheritance to us from our arboreal ancestors, and appear to be formed in the oldest primates by the coalescence of single units which arrange themselves in rows.* Whether or not this phylogenetic or racial stage is now passed through in each human embryo in accordance with the law of biogenesis has not as yet been shown, but it is certain that the ridges are seen fully formed and in their adult condition in a four-months' embryo, and that no change can afterwards take place in any detail.

As these surfaces are thus individually variant and as their condition is absolutely permanent throughout life, they offer the best possible criteria for a system of individual records, especially since they may be so easily recorded by means of printed impressions. All these points have been shown in a practical way by Mr. Galton, who has taken as the basis of his system the markings that cover the balls of the fingers, his 'finger-tips.' The present paper considers the remainder of the ridged surfaces and is thus seen to be *an extension of the Galtonian system to a new territory.* Whether ultimately the universal personal records, which will surely become a necessity in the near future, will be based upon a part or the whole of these surfaces is of no real moment, and it is with the idea of being of genuine assistance to Mr. Galton and without any attempt at rivalry that I offer in the following pages a method of recording identity by means of palms and soles.

M. Bertillon has said that there are not lacking individually variant parts of the body capable of use for purposes of identification, but that what is needed is some system of recording and classifying these differences, so that an individual case can be easily found. The system proposed here will, I think, fulfil this demand, and it will be seen that each human being is as well marked and labeled as though he were tattooed with an individual name and number, the interpretation and manner of cataloguing these devices being the only part not furnished by nature.

The method of printing a palm or sole is a very simple one, and although there are many little details which will occur to one who does much of this work, the essentials are the same in all cases. The outfit for printing consists of a tube of mimeograph ink, a rubber roller such as is used in amateur photography, and unruled paper of the required size. An inking surface is prepared by pinning a sheet of paper to a

* This and other morphological points of which I shall make use in this article are from an unpublished paper upon the morphology of the subject, by an associate in my department, Miss Inez L. Whipple. At my suggestion Miss Whipple has undertaken the comparison of the human conditions of palm and sole with those of the lower primates and other mammals, and has studied also the ontogenetic development of the parts in man and other forms. This work, which is of great value in the present connection, will be published in full in a short time.

board or table, placing upon it a little of the ink, and then rolling it down with the roller until the paper is coated with a uniform thin layer of ink. The best results are obtained when this is thin enough to appear of a dull green color rather than black, and the usual difficulty lies rather in using too much than too little ink. The hand or foot to be printed is then laid upon the inked surface, pressed a little, especially at the places which are naturally raised above the paper, and then removed and laid in the same way upon a clean sheet of paper, pressing the parts as in the first instance. Care must be taken not to slip the hand or foot sideways at any time, as this would blur the lines; a similar condition may be caused by too great pressure, and thus when the feet are taken the subject should be seated, allowing the foot to be manipulated by a second operator. The inking surface should be freshly rolled before each new impression, and when a number are taken at one time, a little ink must be occasionally added and rolled down. If mimeograph ink is not available, ordinary printer's ink will do almost as well, and both sorts may be readily removed from the skin by the use of a little turpentine or benzine, or even by soap and warm water.

After a collection of imprints has been made, the next procedure is the interpretation, that is, the tracing out of certain definite lines which mark the course of the ridges and define the patterns. As the palm presents simpler conditions than does the sole and is much the best for purposes of instruction, we will begin with a good average print like that given in Fig. 1, using a sharp-pointed pencil, and, when necessary, a reading glass of low power. At the base of each of the four fingers there will be seen a triangular area composed of transverse ridges, so intruded into the palm that it parts for some little distance the ridges which belong more definitely to the palm itself. These are the *four digital areas,* and at their apices are found points from which the ridges radiate in three directions, two bounding digital areas and one traversing more or less of the palm. These four points or triradii (equivalent to Galton's 'deltas') are the starting points of the system and may be termed the *four digital triradii,* numbered 1–4, beginning at the inner or thumb side. The lines bounding the digital areas are the *eight digital lines,* numbered from 1–8, and the four other lines which proceed from the triradii and cross the palm are the *four main lines.* These latter, designated by the letters A–D, are of primary importance and furnish by their course the *first* or *primary formulæ* by which the palms are classified. These lines are established by following the direction of the ridges to whatever point they may lead, and are best traced along a certain definite ridge, although, in places where a ridge that is being followed breaks or forks, the line should be continued by means of an adjacent ridge, or by taking the general direc-

tion indicated by several ridges. When the four main lines are traced, search should be made for a fifth triradius, the *carpal,* usually occurring in or near the middle of the palm just above the wrist, and its lines should be followed in the same way as in the other cases. The two short lines running downward to the wrist are the *carpal lines* and define the *carpal area,* and the longer one which curves about the base of the thumb is the *thenar.* A carpal triradius is not always present, but in some cases its place is taken by what may be termed a 'parting,' or a place where the ridges which run from the palm to the wrist divide

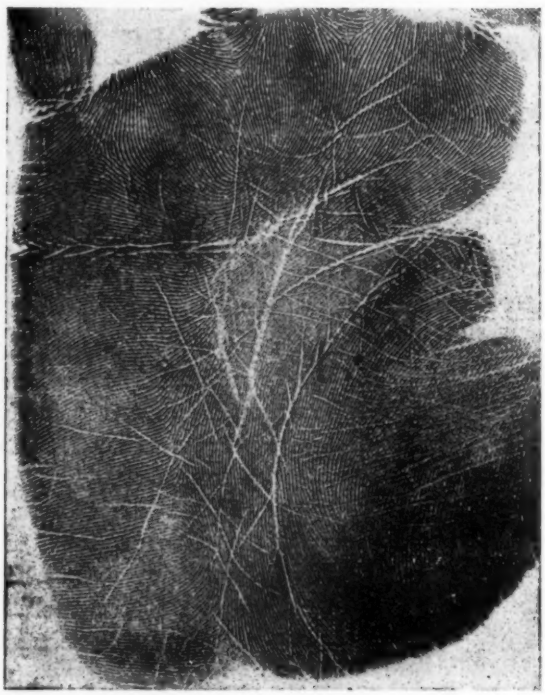

FIG. 1. PRINT OF LEFT PALM [COLLECTION NO. 206], NOT INTERPRETED.

into two groups, one half of which diverge toward the inner, while the other half diverge toward the outer side (see Fig. 4, *a* and *b*). When the interpretation is complete the palm impressions will resemble Fig. 2 (compare with Fig. 1).

If, now, similar impressions are made of a half dozen palms, a great individual difference in the course of the main lines will be at once apparent. They will curve in different directions, sustain various relations with regard to one another and *terminate at different points along the margin of the palm.* Although occasionally two palms will show the same general course of the main lines, there are, on the other hand, a large number of distinct cases, and this system may well serve

for a primary classification, or one which will divide individual records into a large number of sets, as described above in the case of the other two systems. In the former article in this magazine, I suggested this *by applying names to the various areas* marked off by the lines of interpretation, and proposed a set of descriptive formulæ based upon these areas to be used in designating the course of the lines. *I now wish to substitute for this a numerical system,* the *presentation of which in*

FIG. 2. SAME AS FIG. 1, COVERED BY LINES OF INTERPRETATION. Note slight differences in the wrinkles in Figs. 1 and 2, although taken of the same palm at the same time.

the form of a key explains itself (Fig. 3). In this, each triradius and intermediate area is furnished with a number, the latter being designated by the odd, and the former by the even, numbers, and *the course of a given main line may be simply and accurately described by giving the number corresponding to the point at which it terminates.* To the extensive outer border where the use of a single number would be often indefinite, three numbers are assigned, 3, 4 and 5, although where complete accuracy is not needed the symbol 0 (for open) may be used, signifying merely that a given line passes out at some point along the free margin between the outer carpal line and the outer digital one of the little finger. Of these three numbers, 4 is used to designate a

pattern only, which occasionally occurs in this region, and which, when present, defines the territory below it as 3 and that above it as 5. A line entering it and returning along its lower side would be designated as 4/3 (Fig. 4, *d*), one emerging above as 4/5 and one that becomes involved in the pattern and does not emerge is simply 4.

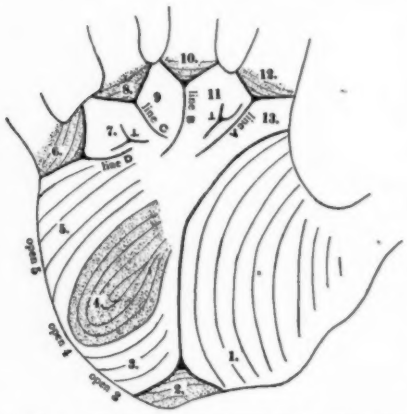

FIG. 3. DIAGRAM OF A LEFT PALM, showing the designations to be used in making the descriptive formulæ. Compare with Fig. 7.

When a pattern is not present in this region, 3 may signify approximately the lower third of the entire outer margin, and 5 the remainder.

In the majority of cases a main line will terminate in one of three ways, it will either (1) open freely along the outer margin; (2) cut through an interspace between fingers or (3) it may fuse with another main line, forming a loop. In this latter case each of the two lines involved may be considered as terminating in the triradius of origin of the other and be described by the corresponding number. Aside from these three possibilities, there is an occasional fourth one produced by the presence of what may be designated '*lower triradii.*' So far as has actually been observed (in above 600 hands) these may occur in but two places, as designated in the diagram (Fig. 3) by inverted ⊥s in the 2d and 4th of the digital interspaces (counting that between the thumb and the first finger as the 1st), but there is morphological ground for expecting one also in a corresponding position in the 3d interspace. When a main line terminates in one of these triradii it should be designated by a ⊥, with an exponent signifying the space to which the ⊥ belongs; thus $\perp^{7}$ or $\perp^{11}$ as the case may be. In addition to these, pattern triradii may occur in connection with the thenar and hypothenar patterns, and of these the second, $\perp^{H}$, comes into occasional relation with line A.

Having now a method by which the course of the four main lines may be designated by means of a sequence of four figures, let us illustrate this by a few cases taken at random, and represented by the tracings given in Fig. 4.

For these the main line formulæ will be as follows:

(*a*) 5.7.9.11.
(*b*) 5.5.9. 9.
(*c*) 2.7.8. 11.
(*d*) $\frac{4}{3}$.6.9.10.

In these the third line of (*c*) is designated by 8, the number for its point of origin, since it exhibits a course not unusual for it, but never found in the other lines, that of running down into a loop and not emerging, so that it can not be said to have a point of termination. In order to obtain formulæ enough to work with, we may add to the above that of the example (Figs. 1 and 2) 2.5.7.9; also those formulæ designating the four palms figured in Fig. 6 of the previous article, viz: (*a*) 5.5.5.7; (*b*) 3.5.6.8; (*c*) $\frac{4}{5}$.6.7.10; (*d*) 5.8.10.11.

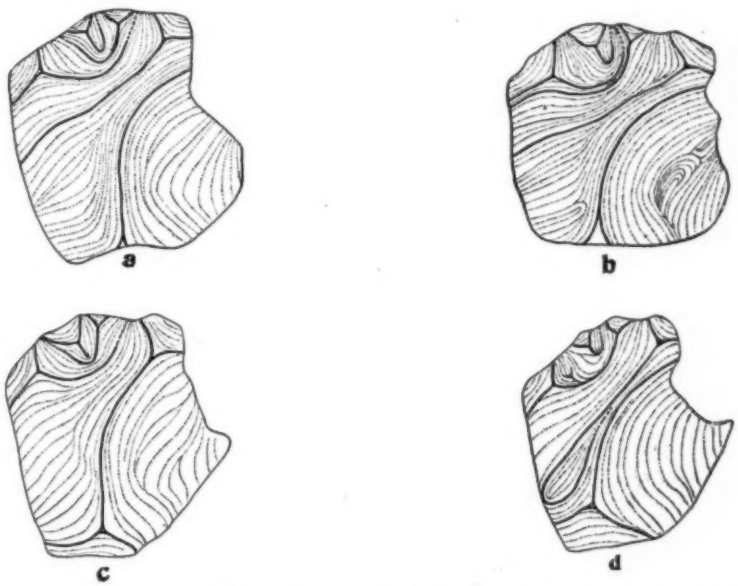

FIG. 4. TRACINGS OF FOUR LEFT PALMS, showing various line formulæ. (*a*) 11.9.7.5 [Collection No. 109]; (*b*) 9.9.5.5 [Collection No. 323]; (*c*) 11.8.7.2 [Collection No. 30]; (*d*) 10.9.6.$\frac{4}{5}$ [Collection No. 32]. In (*a*) there is a parting in place of the carpal triradius; in (*b*) there is a well-developed thenar pattern; in (*c*) line *C* is very short and runs into a loop where it ends abruptly; in (*d*) the third lower triradius is present, assisting in the formation of a pattern.

To arrange these or any number of formulæ in definite order it will be necessary only to make the first subdivision in accordance with the first designation (*i. e.*, that of line A) and so on with each designation in succession, employing the usual numerical sequence. A fraction may be marked by its numerator alone, since the denominator is nothing more than an added specification or descriptive mark, and the sign ⊥ may take precedence of all, ranking before the figure 1. By this means the nine formulæ referred to above would be arranged as follows:

2.5.7.9.	$\frac{4}{5}$.6.7.10.	5.5.99.
2.7.8.9.	$\frac{4}{5}$.6.9.10.	5.7. 9.11.
3.5.6.8.	5.5.5.7.	5.8.10.11.

Although, as given in all of the above illustrations, the natural order of sequence in the four designations of each formula is from the line A to line D, it happens that of the four, A is the most uncertain in its interpretation, and is the only one concerning the designation of which differences of opinion would be likely to occur. It is unfortunate to begin with this especial one and thus be liable to be put on the wrong track at the outset, and it appears to be better to *reverse each formula,* beginning with line D and ending with A. This would lead to a rearrangement, not only of each formula which would be simply reversed, but also of the order of sequence of the whole, so that the nine formulæ used above would become rearranged as follows:

7.5.5.5.	9.8.7.2.	10. 9.6.4.
8.6.5.3.	9.9.5.5.	11. 9.7.5.
9.7.5.2.	10.7.6.4.	11.10.8.5.

in which a given formula would be as easily found as in the other order, with the advantage of having the uncertain designation in the fourth place instead of in the first.

Of course it can not be known, at least as yet, what is the total number of *main line formulæ* which occur in the human hand, but in this regard the following table will be of interest, which gives in the regular order of sequence the formulæ of the hands of 100 American female college students, 100 rights and 100 lefts, and shows the number of times each formula occurs in each hand.

TABLE I.

Formulæ.	L.	R.	Formulæ.	L.	R.	Formulæ.	L.	R.	Formulæ.	L.	R.
⊥³. 7.5.5	1	1	8.6.5.5	2	6	10. 7.6.5	3	4	11. 8.7.2	1	2
⊥³. 8.7.5	1	0	8.7.6.5	0	1	10. 8.6.3	0	1	11. 8.7.3	1	0
⊥³. 9.5.5	1	1	9.7.5.⊥¹	1	0	10. 8.6.5	1	2	11. 8.7.4	0	2
⊥³. 9.7.5	0	1	9.7.5.1	1	0	10. 9.6.2	1	0	11. 8.7.5	4	3
⊥³.10.8.11	0	1	9.7.5.2	3	1	10. 9.6.3	1	0	11. 8.9.5	0	1
7.⊥³ .5.4	0	1	9.7.5.3	3	2	10. 9.6.4	1	1	11. 9.7.⊥ᴴ	1	1
7.5.3.2	1	0	9.7.5.4	0	4	10. 9.6.5	2	2	11. 9.7.⊥¹	1	0
7.5.5.2	2	0	9.7.5.5	5	11	10.10.6.5	0	1	11. 9.7.3	2	1
7.5.5.3	6	1	9.8.5.3	4	1	10.10.8.5	0	1	11. 9.7.4	2	0
7.5.5.4	1	1	9.8.5.4	1	0	11. 7.5.3	1	0	11. 9.7.5	4	22
7.5.5.5	2	2	9.8.5.5	2	2	11. 7.5.5	1	0	11.10.8.⊥¹	0	1
7.9.5.3	1	0	9.8.7.5	0	1	11. 7.7.1	1	0	11.10.8.4	1	0
7.9.5.5	0	1	9.9.5.3	1	0	11. 7.7.2	1	0	11.10.8.5	1	4
7.9.5.11	1	0	9.9.5.5	2	2	11. 7.7.3	1	1	11.11.8.5	0	1
8.6.5.2	2	0	10.7.6.2	5	0	11. 7.7.4	1	0			
8.6.5.3	9	4	10.7.6.4	1	0	11. 7.7.5	8	4			

By this it will be seen that the total number of formulæ represented in the 200 hands is 61, that there are 48 separate formulæ in the left hands and but 38 in the right. Of the 48 left hand formulæ 23 do not occur in the right, and of the 38 right hand formulæ 13 are not found in the left, 25 being common to both. The commonest formula

for the left hand is 8.6.5.3., which occurs in 9 per cent. of the cases, while for the right hands the commonest formula is 11.9.7.5., occurring in 22 per cent. of the cases. The records from so small a number of cases can not be conclusive, but it would seem both by the number of formulæ represented and by the smaller percentage of occurrence of the commonest formula that the left hand is much more variant.

From this table there may be also calculated the amount of latitude allowed in the positions assumed by each line and the percentage of occurrence of each terminus of each, the results of which are given for convenience in a separate table, as follows:

TABLE II.

Terminus.	Line D.			Line C.			Line B.			Line A.		
	L.	R.	Both.	L.	R.	Both.	L.	R.	Both.	L.	R.	Both.
$\perp^{H}$	—	—	—	—	—	—	—	—	—	1	1	2
$\perp^{1}$	—	—	—	—	—	—	—	—	—	2	1	3
$\perp^{2}$	—	—	—	—	—	—	—	—	—	—	—	
$\perp^{3}$	3	4	7	—	1	1	—	—	—	—	—	
1	—	—	—	—	—	—	—	—	—	2	0	2
2	—	—	—	—	—	—	—	—	—	16	3	19
3	—	—	—	—	—	—	1	0	1	30	11	41
4	—	—	—	—	—	—	—	—	—	8	9	17
5	—	—	—	12	4	16	53	41	94	40	74	114
6	—	—	—	13	10	23	15	12	27			
7	14	6	20	37	29	66	29	38	67			
8	13	11	24	15	15	30	2	8	10			
9	23	24	47	21	32	53	0	1	1			
10	15	12	27	2	8	10	—	—				
11	32	43	75	—	1	1	—	—		1	1	2

It will be seen by this that the commonest position for line D is 11 (between the index and middle fingers), a position which occurs in 75 out of 200. Similarly the commonest position for line C is 7; for line B, 5; and for line A also 5; but, curiously enough, the commonest actual formula is not 11.7.5.5., the combination of these. This table also shows that line D may oscillate in its position from the interspace between the ring and little fingers to that between the middle finger and the index; that line C swings between an open position and the same limit as that of line D, and so on.

In the employment of these line formulæ as a primary classification it seems advisable for several reasons to employ that of the left hand first, which will be seen to divide a series into between 40 and 50 compartments, and since the right hands appear to vary independently or nearly so, the addition of the line formulæ of those would subdivide each of the 40 or 50 into about the same number of lesser compartments, or in all approximately 45^2 or 2,025.

That is, if the hand-prints of a city of 100,000 inhabitants were arranged in accordance with the line classification alone, there would be needed over two thousand compartments, with, theoretically, about

50 in a compartment. As practically worked out, the distribution of these prints in compartments would be an unequal one, and while certain of the compartments would have but a single representative, or be even empty, some of the others would have a much larger number than fifty, possibly even several hundred.

But the line formulæ are but a primary classification and do not by any means exhaust the resources of these very varying parts. As a *secondary classification,* for the farther subdivision of the palms, to be appended to the first and employed whenever expedient, the use of a *pattern formula* may be suggested. This is based upon the irregular occurrence of patterns such as occur normally in the simian hand and appear sporadically upon various localities of the human palm.

If we count as a pattern each place where there is a definite loop, whorl or noticeable disturbance of the usual even course of the ridges, although by doing so we violate certain of the underlying morphological principles as shown by the comparison with other mammals, we may expect to find any or all of five patterns, located as described in the previous article and corresponding roughly to the divisions into which the palm is divided by the lines of interpretation, viz., one *thenar,* one *hypothenar* and three *interdigitals* (*palmar* of the previous paper). Of these the thenar, of rare occurrence among people of the white race, is morphologically composed of the vestiges of two, a genuine thenar and the interdigital which corresponds to the interval between the thumb and index; the three interdigitals lie below the three intervals between the fingers from the index to the minimus; and the hypothenar appears upon the large eminence of the same name which forms the outer boundary of the palm.

A pattern formula will thus need five places, one for each of the five patterns in a prearranged order, and, again adopting the principle of placing in the first position a very obvious one, about which there is no doubt, the order suggested may be, *hypothenar, thenar, first, second* and *third interdigital.* When any one of these is present, it may be designated by an abbreviation, such as a capital H for hypothenar, Th (or better, the Greek θ) for the thenar, and 1, 2 and 3 respectively for the others. When absent, 0 may fill the position, and when there is merely a rudiment, a small r may be added to the 0 as an exponent. Thus a few representative pattern formulæ would be the following, taken from actual cases:

H.0^r.1.2.3	0. 0.0.0.3
H. 0.0.2 3.	0.0 .1.2.3.
H. 0.0.0.3.	0. 0.0.2.3.
H. 0.0.0.0	0. 0.0.2.0.
0. 0.0.2.0.	0. 0.0.0.3.
0. 0.0.2.0.	

The order of arrangement for each position would be naturally to consider the signs of the patterns as precedent to zero, an arrangement which it will be noticed, has been followed in the above list. A rudiment, like Galton's descriptive suffixes, is disregarded in the arrangement, and counts like other zeroes.

FIG. 5. PRINT OF A RIGHT SOLE [COLLECTION NO. 112] SHOWING A HIGH DEGREE OF COMPLEXITY, and presenting difficulties in formulation. There are two lower triradii, probably the first and second, in which *D* and *B* [IV and II] terminate respectively; the triradius of line *C* [= III] is beyond the limit of the print and its location is in part conjectural; the second and fourth digital lines curve downward across the palm.

Morphologically the same pattern, *i. e.*, one in a given position, may differ considerably in regard to its mode of formation, the presence or absence of 'pattern triradii' or those concerned in its structure, the shape of the pattern itself, its degree of completeness and so on, and all these attributes may be easily added by means of a series of easily devised descriptive signs, like the 'descriptive suffixes' of Galton, and used as exponents, having, like the exponent *r*, no influence upon

the arrangement of the formulæ, but simply completing the description.

Should a third classification be necessary, the presence, position or absence of the carpal triradius would furnish one, and for a fourth subdivision a counting of certain of the ridges, like those between the digital triradii as Galton does in his finger-tip system, might be suggested. In the last instance, where the decision of a definite case rests upon the identity of a certain individual, actual prints taken from his palms should be compared with the set in the collection which most closely corresponds in the formulæ to them, and the decision should be reached by the study of the minutiæ, *although there could hardly be a mathematical chance of a comparison going as far as that unless it was a case of actual identity.**

FIG. 6. TRACINGS OF THREE LEFT SOLES, showing various relations of digital and main lines. (*a*) Lines *A*, *B* and *D* are open; line *C* is recurved and opens at 9; the third digital line is recurved around a pattern: the first and second digital areas are confluent; there is a single lower triradius [Collection No. 156]. (*b*) Lines *A* and *B* are open: line *C* is recurved; line *D* terminates in a lower triradius (the third?); the digital lines are all normal and the digital triradii are distinct; there are two lower triradii [Collection No. 86]. (*c*) Lines *A*, *C* and *D* are open; line *B* is recurved around a pattern and fuses with one of its own digital lines; the digital lines are in general much modified and the digital areas are all confluent; there is but one lower triradius, the first [Collection No. 59].

The previous pages have treated of the hands alone as though they were the only possibility of the system, but the soles of the feet exhibit fully as great a diversity in the course of their ridges, and their use in addition to that of the hands would furnish so complete a means of subdividing a collection of prints that the secondary classification, *i. e.*, that which concerns the patterns and the carpal area, would hardly be necessary except to complete a description. The feet as well as the hands possess four main lines originating from the digital triradii, and as their formulæ are nearly as variant as are the others, the subdivisions rendered possible by the use of all four members are well-nigh infinite in number (see Figs. 5 and 6).

* Consult in this connection my comparison of identical twins, which are in all probability nearer alike in the palm and sole markings than are any other two human beings, and which nevertheless differ to a noticeable degree in the minutiæ. *Amer. Jour. of Anat.*, Vol. I., No. 4. 1902.

Thus if, as shown above, a set of formulæ would be divided into upwards of 50 divisions by using the left hand alone, and if each of these would be farther subdivided by adding the formulæ of the right hand, producing 2,500 divisions in all, the addition of the left foot to these might increase the number to 2,500 × 50, or 125,000, and these would become 7,250,000 by the use of the right foot, or enough to characterize every citizen in a large state or small country, employing merely the *primary* classification. It must be remembered, however, that these are theoretical figures and that the actual combinations of lines may not be as great, nor would the various kinds be as regularly distributed; yet enough has been shown to prove that the number of separate actual combinations of the line formulæ alone, if both the hands and feet are employed, would be very great.

In a sole print the characteristic features are mainly distributed along the ball of the foot, anterior to the hollow of the arch, and while in a general way they are similar to those of the hand, there are also numerous important differences, some of which will be seen in Fig. 5, a print which represents a more complex condition than is usually seen, and in the tracings given in Fig. 6. The four main lines of the sole, although arising from digital triradii, usually curve towards the inner instead of the outer side, and when open, are apt to converge at the inner margin almost or quite to the point of fusion. There is also almost always upon the thenar region or ball of the great toe a conspicuous pattern, which may be termed the *hallucal* pattern. This possesses one or two, and possibly three triradii, of which the upper one is the proper digital triradius of the great toe, usually unrepresented in the hand; while there is often a second one upon the extreme inner margin, sometimes shown only by rolling the foot a little during printing. The hallucal pattern shows much variation and is easily divisible into a series of types, which well serve the purpose of a secondary classification. Lower triradii are of far more frequent occurrence than in the hand, and are often located so near one another through the convergence of the interdigital areas that it is difficult or impossible to attribute them to any one of them.

Probably the greatest barrier to the formulation of sole conditions in the same way as in the case of the palms lies in the position of the digital triradii, which are apt to be situated in the hollow beneath the toes and thus beyond the margin of a print—a condition especially apt to occur in the case of the third one, *i. e.*, that at the base of the fourth toe; again, the relationships of the triradii are often complicated by the fusion of two or more digital areas with one another and the consequent displacement of the digital lines, which may simply pass one another upon the digital areas or curve downwards over the ball of the foot as

is the case with the second and fourth digital lines in the print given here (Fig. 5).

These difficulties, especially that of the extra-limital position of the digital triradii, certainly prove a barrier towards the application of the same system as in the palm; yet, with some adjustment to conditions, this would still seem to be feasible. A diagram assigning numerical designations to the different terminal regions is given here (Fig. 7) which may be compared with the similar one referring to the palm (Fig. 3).

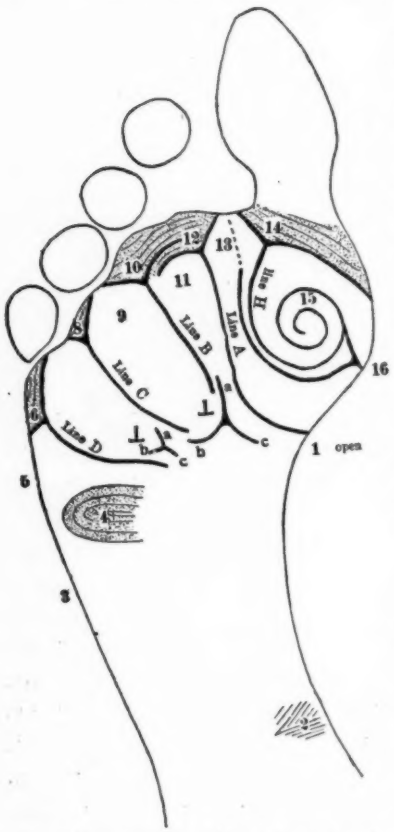

FIG. 7. DIAGRAM OF A LEFT SOLE, showing the designations to be used in making the descriptive formulæ. Compare with Fig. 3.

A more detailed account of the sole formulation is not within the space limit of the present article, but enough has been given to suggest how this may be accomplished. I would especially emphasize the practicability of the use of the hallucal pattern, perhaps even in a primary classification, which recommends itself by its large size, its conspicuous character, and its ready divisibility into definite types.

Lastly, there remains only a short discussion of the means of recording and filing away prints, the amount of space they would occupy and their consequent feasibility as a means of recording all citizens, as advocated in the previous article. The prints themselves should be taken upon smooth but not glazed unruled paper of a suitable size, one of about 35 x 21.5 cm. (14 x 8½ inches) for the hands, and one of 35 x 28 cm. (14 x 11 inches) for the feet. Upon each of these the respective prints should be arranged in the natural order, that is, the left upon the left side, etc. There is enough blank paper left in such a piece to record any details necessary about the person; the name, date of birth, nationality, and even the Bertillon measurements.

As in the Galton system the formulæ may be written at one end, most conveniently the left, so that an especial case could be found by turning over a pile of papers as in selecting a page in a book; or else

each set of prints may be simply numbered, and placed consecutively in shallow drawers, with 50–100 in a drawer, while the classification may be made by means of a card catalogue, which would contain a numbered card for every individual, arranged in accordance with the system just described. I have arranged my own print collection upon this latter system, the prints being numbered and arranged consecutively in the order taken, while the corresponding cards are classified in accordance with the formulæ, those of the left hands taken first, and subdivided by those of the right.

As for the space required for a collection. If the prints are filed in shallow drawers or slides holding 50 sets each, a collection of 100,000 sets could be accommodated in 2,000 drawers; and allowing a frontage of 16 x 2 inches for each drawer with its surroundings, these would make a cabinet 6 feet high and composed of 56 perpendicular stacks which together would occupy a wall length of 75 feet. An 18-drawer card index with a capacity of more than 20,000 3 x 5-inch cards, as taken from a recent catalogue of office furniture, is 44 inches wide and 14 in height, and the five necessary to accompany the collection in question would form a single stack 6 feet high and 44 inches wide, which will add approximately four feet to the seventy-five given above. Thus a room having 80 feet of wall, linear measure, or a smaller one with a double stack running through the center, would be amply sufficient for the entire collection, properly arranged.

This calculation appears to answer in the affirmative the question of the practicality of keeping palm and sole records of all citizens as advocated in my previous article. M. Bertillon has pointed out the numerous cases in civil life in which one's identity is in peril, and looks forward to a future in which some record, based upon physical characters, will be made of every citizen, but the trouble and inconvenience attending his own system of measurements and the fact that they are applicable during adult life alone, would leave them hardly to be considered for such a purpose.

The palm and sole system, which I originally presented as an extension of the system of Mr. Galton, appears to supply the need in this respect, as the records are easily taken, unchanged from birth to death, quickly compared, either with the hands and feet themselves or with other prints, and capable of brief characterization and of accurate classification by means of simple formulæ, to all of which may be added, as their most important advantage, that of absolute certainty, while the Bertillon measurements afford no more than a strong probability.

Prints could be taken in each township or municipality, and filed away in any convenient spot, perhaps the court house of each county

seat. They could be taken in connection with the school registration, either when first entering, or better yet at the age of twelve to fifteen. There can be no question as to legal right in compelling such records, since there is no serious objection to compulsory vaccination, a far more serious operation, and one incurring a slight indisposition and a permanent change in the system, the nature of which is as yet unknown.

Similar records could be taken by the various civil and religious institutions in which the identity of an individual is apt to be called in question. Banks could require an imprint of the left palm upon the inside cover of bank-books; business men could issue checks with a fac-simile engraving of the palm of their own left hand covering the face; insurance companies could keep a palm and sole list of their clients; the Geary law would be rendered a certainty if the certificate issued to each Chinaman bore, besides the photograph, a single palm print, and churches could file away palm and sole prints with their baptismal records.

In the words of Bertillon, the founder of anthropometric identification: "La constitution de la personnalité physique et de l'indéniable identité des individus arrivés à l'âge adulte répond, dans la société moderne, aux besoins les plus réels, aux services les plus variés. . . . En un mot, fixer la personnalité humaine, donner à chaque être humain une identité, une individualité certaine, durable, invariable, toujours reconnaissable et facilement démontrable, tel semble l'objet le plus large de la méthode nouvelle."*

* 'Instructions signalétiques,' 1893, Introd., p. lxxxiii.

SOME OF THE EXTRA-ARTISTIC ELEMENTS OF ESTHETIC EMOTION.

By JOHN COTTON DANA,
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MY work in a library has brought me in contact with the art interests of a great many people. Most of these people have been of the average, well-to-do, clerical, commercial and professional classes in this country. Representatives of women's clubs and of art classes of all kinds have been common among them. Many had traveled or were making studies preparatory to visits to art centers abroad. The modern public library thinks the promotion of interest in art in its community is a proper part of its work. With this in view it buys expensive books on art and photographs of paintings, sculpture, architecture and other things in the field of art. The library's close connection with the schools also makes it easy for the librarian to keep in touch with their work in drawing, design and general art instruction. I have had unusually favorable opportunities to learn about the art interests and the esthetic perceptions of that very interesting class of American women, the public school teachers. From them and from supervisors of drawing in the schools I have learned something of the interests of children in pictures and of their capacity for esthetic cultivation. The libraries I have been connected with have made great use in the schools of illustrations and decorations found in certain periodicals; not only of pictures from art journals, but also of material published, not for its art interest, but for its illustrative interest. For students of design, collections have been made of head- and tail-pieces and initials, from many sources. Designs for wood carving, embroidery, iron work and the like have been gathered and arranged. Illustrations have been collected—sometimes by the children themselves—and arranged by artists, by subjects, by methods of reproduction and by media used in the original. Collections have been made for story-telling purposes, and to illustrate history, geography and nature-study. Reproductions of famous paintings, sculptures and buildings have been gathered and classified. I speak of this by way of introduction; to explain my interest in the subject of art; and to give grounds for presuming to speak upon it. The collecting of these pictures, the purchase of art books and the encouraging their use have naturally brought me into close touch with the very representative

group of Americans who patronize the free public library. I believe I know something about their way of looking at the subject of art; and that I know, consequently, how art is regarded by about 99 per cent. of the fairly well-to-do and moderately rich in this country. My interest in the subject, enhanced by the opportunities I have mentioned, has naturally led me to take note of art in the American home, and of the light it throws on the art knowledge and esthetic sensitiveness of the American people. My observations in this direction have confirmed me in the conclusions, herein noted, to which my work in the library had led me.

Most discussions of esthetics ignore certain common, every-day feelings which seem to be important factors in the appeal which works of art make on our attention. I have here tried to describe the nature and origin of some of these feelings, and to show that they are among the most universal and the simplest elements of esthetic emotion. I call them extra-artistic elements, because by the professional artist they are not considered to lie within the artistic field.

The physiological factors in esthetics are, in a certain sense, more fundamental than the familiar feelings I discuss in this essay. They go to the very bottom of the pleasurable sensations which the sight of certain objects gives us. But we do not yet understand them. A spot of color probably gives pleasure—under proper conditions—even to the most uncultivated observer. Savages and even some of the lower animals have this much of esthetic feeling. Meaningless arrangements of several colors probably give greater pleasure to some, even of the entirely untrained, than does the single spot of one color. Flat design in black and white, quite without suggestion of any kind, arouses agreeable sensations in some, but probably only in a few of those who have never given thought to the subject. That is, pictures, considered simply as flat, colored designs with no regard whatever to what they portray, may produce an agreeable physiological effect on some of those who see them. This direct physiological effect is, as I have said, little understood. It sometimes, perhaps commonly, forms a part of the group of pleasurable feelings which picture-gazing evokes. It is fundamental to be sure; but with nearly all observers it is of slight importance in comparison with the mass of agreeable sensations whose nature and genesis I have outlined below.

Most of us first note a picture which we know is popularly admitted to be a work of art with a pleasure which comes of being in the fashion. It is the custom to enjoy it. We like to know and feel that we are following the custom. We find it easy to say, as all others do, that it is pretty and attractive; and so saying we get the pleasure of conformity; of being in the mode. This kind of picture-enjoyment lies upon the surface, is easy to acquire and comes naturally to all of

us; and any picture which has once gained wide repute, thereby gains popular esteem, gives much pleasure, and seems to serve a proper purpose by virtue simply of being in the fashion, even though it have little to commend it to the wise critic. The word fashion carries often an implication of censure. Such censure is not intended in this case. To wish to see what others have seen is natural and proper. The mistake would lie in assuming that this kind of pleasure from picture-gazing is not present with all of us, and is not a proper element in esthetic emotion.

To see old friends again after a time of separation always gives us pleasure. The emotions which go with the act of recognition are so generally agreeable that we greet with considerable warmth of feeling even those old acquaintances we have never much cared for if we meet them after long separation or at a distance from the scenes where we once knew them. This recognition-element among the factors of pleasurable emotion lies at the bottom of much of our joy in the familiar quotation, of our admiration for the classic in literature and the familiar in art. A picture often spoken of, often alluded to in print, seen occasionally, even in the simplest or crudest reproduction, is at once recognized, and at once gives us the pleasure of recognition, when seen again. This manner of picture-appreciation lies, of course, close to the pleasures of memory, to the indulgence of habit, and to the complacence of conservatism; just as the pleasures aroused by the picture which it is the fashion to admire lie close to the self-satisfaction born of conformity to the prevailing moral code. These fashionably-born and habit-bred emotions form a large part, a very large part, of the delight we find in picture-gazing. Art galleries are full of people who gain little from their visits there beyond these simple and familiar emotions. Yet in the discussion of esthetics they are commonly almost ignored. The origins of the feelings which are aroused by works of art are assumed to be complex, peculiar and quite remote from every-day life; whereas the most dominant of them lie close at hand, in conformity and habit. In the field of literature we see this truth very clearly illustrated. The classics of one's native tongue are chiefly enjoyed because they are familiar. Often, probably commonly, they have a power to move us which is due to their content, or to our knowledge of the peculiar circumstances under which they were produced, or to their relation to a widespread creed, or to the personality of their writers, or to the influence of their promoters or expositors, or to their particular aptness of phrase, or to the peculiar sensitiveness of a few of their many readers to the spell wrought by special arrangements of words. But, once having become imbedded in the popular mind, once having become the accustomed reading of a generation or two, they hold their power very largely through the fact that they are easily

recognized, are habitual visitors, and arouse often the joy of recognition. The St. James version of the Bible is perhaps an example of the best possible use of the English of its time. But of this we cannot be sure. As a book it has long been popular—on other grounds than those of style. Being popular it molded our forms of expression for generations. All our speech harks back to it. To read it is to catch in every phrase a pleasing echo of the language of our own time, and this regardless of the agreeable familiarity of thought and incident. We recognize it, and delight in it. If circumstance had cast that version into a different form we should, no doubt, admire it none the less; and our language would be different from what it now is, perhaps better.

Allied to both fashion and recognition as an element in esthetics is curiosity; not the inquiring curiosity of the seeker, but the passing curiosity which we take in uncommon things. The picture much talked about—this is the one we wish to see. Having seen it the emotional tension is relaxed, and we have an agreeable sense of satisfaction. Near to this and perhaps part of it is the pleasure given by the sight of a picture which is rare or ancient or high in price, or one which was made with much labor or with unusual technical skill. The patch-work quilt of a thousand pieces made by a woman of seventy-five without the use of glasses, this gives great pleasure to its observers. It is a curio. To most observers it is looked at with a pleasure of like origin to that with which they gaze upon a painting by an old master. I am not condemning this form of emotion. I am simply setting it down where it belongs as forming a part in many cases of the pleasure of picture-gazing, as a part of esthetic emotion. Much of the furnishing of the homes of people of wealth and cultivation—being rare, costly and representative of great labor and much technical skill —gives to its owners a pleasure of like origin with that imparted by the crazy quilt.

Kinship in knowledge is a bond of friendship. The beginning of sympathy is like-mindedness. We cannot care much for those we do not know; we know those who know the things that are known by us. Meeting in a distant land one alien to us in every way, but familiar with the same home scenes, a friend of friends of ours, we have for him at once a touch of sympathy, and find pleasure in our meeting. So, if we look upon a picture in company with others who are with us in our enjoyment—even when, as is most often the case, the enjoyment is born of fashion, habit and curiosity—we have a sense of companionship with them, a pleasurable feeling born of a common interest, which we ascribe as to its origin to the picture itself. In fact, the picture, as a work of art, is not the cause of our enjoyment at all. A tight-rope walker or a sacred relic would serve as well; perhaps better in many cases. We simply have widened and increased our

sympathies through the acquisition of a new point of contact with our fellows.

Almost all pictures tell a story. Those which seem not to do so at first sight are usually found to be full of meaning on second look; and a very large proportion of all the pictures most commonly seen, those in the illustrated journals, are intended almost solely as aids to narration. Stories are dear to us all. We are eager to hear them, to read them, and especially to see them. One that is told by a picture, and so is flashed upon the mind in a glance of the eye, adds to other possible excellencies those of brevity and surprise. In a picture we look usually first for what it tells—that it gives us, in a flash, a bit of life from a new point of view, seen in a different light, touched with humor, pathos or other sentiment—this is commendation enough. A portrait is to most a story picture. It tells more about the person portrayed than many pages of biography, and interests chiefly by what it tells.

It is usual to decry this story-telling element in pictures. Mr. John C. Van Dyke, for example, in his book on 'Art for Art's sake' speaks of 'The Angelus' as having a 'literary interest crowded into it to the detriment of pictorial effect.' We can not see in the picture, he says, 'the sound of the bells of the Angelus coming on the evening air, from the distant church-spire.' 'We must go to the catalogue to find the meaning of those two peasants standing with bowed heads in a potato field.' And he says, that, 'two thousand years hence, with the ringing of church-bells abandoned and forgotten fifteen hundred years before, we would not comprehend and appreciate the picture as we now do a Parthenon marble.' Mr. Van Dyke forgets that the Parthenon marble itself also tells a story; and that it is because we know the story well, because Greece and its religion, its social life and its art are familiar that we comprehend and appreciate at once even a fragment of that country's creations. The fragment arouses our recognition-pleasure, and most strongly. It appeals to us also by what it tells of the past; it tells it easily because we are full of a knowledge which makes us fit to receive it. Suppose Greece and her temples forgotten, a Parthenon marble would be beautiful still, probably, but it would be no more easily comprehended and appreciated than would 'the Angelus' if church-bells had passed out of human memory. All pictures are illustrative; all are story-telling in a measure. It is inevitable that they should be so. They can not, as Mr. Van Dyke seems to wish to have them do, 'show deep love of nature per se, independent of human association.' The question of illustrative intent is entirely one of degree. Nor is there any rule whereby one can say how much of this element a picture should contain. There it is; there it must be. It is good, and we may rejoice that it adds its force to that of the other factors in the delights of picture-gazing.

To the story element in pictures as a cause of our enjoyment of them we must add another element closely allied to it, that of history. The historical picture is always a story picture; but it usually tells to an observer more than a mere story. If we are ourselves already familiar with the incident depicted, we gain from looking at the picture the recognition-pleasure already noted. If we are not familiar with it we take pleasure in adding to our historical knowledge the particular incident set forth in the picture. That is, in looking at historical pictures we either pride ourselves on a recognition which assures us that we are so far well-informed, or we please ourselves by adding to the sum of our knowledge.

Knowledge of the life of an artist, of his peculiarities, of striking incidents in his career, of the country and the time in which he lived —this knowledge adds much to the pleasure gained from pictures. A glance at one, if it is recognized as by an artist of whom the observer already has some knowledge, gives first the pleasure of identification or naming—not different from that which one has who can name on sight a distant mountain peak—and next, through association the pleasure of recalling, even though vaguely, facts in the artist's life. Much of the pleasure won from pictures lies in this identification-emotion.

The pleasures thus far noted as derived from pictures are not derived from pictures only. We get the same enjoyment from looking at scenes upon the stage, at photographs of nature, at nature herself, at incidents in real life about us and from poetry, story and literature in general. This is equivalent to saying, and the saying is a true one, that most of the enjoyment of pictures is due to effects not at all associated with or flowing from 'art' as that word is generally used by artists. The artist himself, however, is by no means free from the influence of the factors already enumerated. From time to time, in his development as an artist, he has undoubtedly tried to free himself from what seemed to him the embarrassing limitations of the habit, formed in youth, of getting from pictures pleasures born of fashion, curiosity, sympathy and story. He never succeeds in doing this. He sees all pictures as he does all art—as I have said in discussing the presence of the story element in all art—through the medium of his own past experiences and of his own character. He sees them first as an animal, as a social being, as a person fashioned by the age and country in which he lives. As an artist, however, as a person skilled in his calling, the things that usually most interest him are technique, design, color, light and shade, line, and manner of laying the paint on the canvas. It has probably always been the fashion for artists themselves to speak rather scornfully of the interests aroused by and the pleasure taken in pictures from the point of view of the story or of

the other elements already mentioned, and to think of them as lying outside the field of art proper. But the artists who are of the broader view readily admit the importance in painting of these extra-artistic features. From the point of view of craft, of technical skill in painting, these matters of line, and color, and light and shade, and arrangement, and method of applying paint, all are of great importance. But only with the craftsman who is unduly interested in the question of skill do these purely artistic matters seem of greater importance than the factors of enjoyment already mentioned.

If I have been right in this analysis of the pleasures gained from pictures, we may describe the picture-gazing of the average person somewhat as follows: He likes the color; he likes to look because others look; he likes to look because he enjoys seeing an old friend; because he has the habit of looking; because he enjoys seeing the curious; because he enjoys the sympathy with his fellows which comes from enjoying the same objects with them; because he enjoys the story of the picture; because the picture renews for him an incident in history; because considered simply as a design the picture is to his thinking well made and he finds agreeable the relation of its lines and its colors and their arrangement, their harmonies and their contrasts; and because, having skill as a painter, or knowing of that skill, he is interested in the manner in which the artist in question laid on his paint.

These remarks on some of the simpler elements of esthetic emotion as shown in picture-gazing may seem commonplace, may seem too obvious to be worth the saying. But the obvious and the commonplace —these very often escape us. They are particularly ready to do so when we speak of beauty, art and esthetics. In this field words are very often merely counters, not real coin. All of us have our pleasurable emotions when we look upon beautiful things, else why do we call them beautiful? And the very words in which we speak of things of beauty seem themselves to have a power to move us; and we ascribe to them meanings when in fact they are often only meaningless echoes, faint, but still able to stir our emotions.

Beauty as a factor in the pleasures of picture-gazing, this I have not named. Yet the whole discussion is concerning it. For, if a picture, or any other object gives us the pleasure described it must possess the subtle quality of beauty. That quality itself cannot be described. When we see a beautiful thing we know it. What more can be said? If experts, who are careful observers of the things which people say they find beautiful, if experts in esthetics say the beauty of a certain object is of the better kind, their statement is worthy of attention. It is difficult to say of beauty and the critics more than this.

KARL LAMPRECHT AND KULTURGESCHICHTE.

By Professor WM. E. DODD,
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DURING the last ten years a fierce war of words has been waged in Germany concerning the nature and scope of history. It is known as the 'Kampf um die Kulturgeschichte' and almost every historical scholar in the Empire has been forced to take either the one side or the other. This 'Kampf' which seems to mean so much for history and its writing began in 1893 with the appearance of the first volume of 'Deutsche Geschichte' by Karl Lamprecht, professor of history in the University of Leipzig. Leipzig and Berlin have been the centers of the opposing forces, and seldom has a learned controversy been conducted with so much animus. The question at issue is: Is history a science or an art? Lamprecht boldly asserts that it is a science, while his opponents maintain that it is and must always remain an art. The adherents of Lamprecht have been dubbed 'Lamprechtianer,' while the enemies of the new movement call themselves 'Jungrankianer.' It will thus be seen that the name and fame of the great Ranke have been enlisted on the conservative side of the dispute.

American scholars have troubled themselves but little about a contest both sides of which are supported by so much of truth. In fact little has been said or written in this country about Lamprecht or Delbrück, the leading champion of the Ranke school. Only one article and one review have come to the attention of the writer; the article appeared in the *American Historical Review,* of April, 1898, the review in the same publication of July, 1902. Yet the word 'Kulturgeschichte'—Lamprecht's slogan—is not unfamiliar to most of us, and quite often in addresses and papers on history and its teaching the principles laid down in the works of the Leipzig professor are given no little prominence. In some quarters, however, the unconscious Ranke influence has found expression in slurs on the claims of 'Kulturgeschichte'—history as a science, as Lamprecht insists. Still it is safe to say that the ideas advanced by the new school of German historians find a more general acceptance in our country than in any other, and this without our knowing just how it comes about. The cause of it is, perhaps, the reasonableness of the tenets of the Lamprecht school, the practical cast of mind of American scholars and our comparative freedom from the trammels of tradition and class prejudice.

Karl Lamprecht was born near Wittenberg in 1856; received his earlier training at Pforta, the celebrated Prinzenschule, and won his Doctor's degree from the University of Leipzig in 1879. The student was father of the scholar; his thesis was of such extraordinary character that the department of history to whose head it was offered refused to accept it. So the present head of the same department was compelled to take his degree as a political economist. Young Lamprecht was scarce hopeful of entering upon the professorial career, so scant were his means and so expensive it was and now is in Germany to become an instructor in a university. He engaged himself to teach in a private family in Köln, but while employed in this capacity he unexpectedly attracted the attention of a wealthy burgher of that city named Mevissen, who supplied him with the means of entering the University of Bonn as a docent—usually the first step to a professorship. Lamprecht's initial work, the investigation of the condition of the peasantry of the Rhineland at all stages of German history, brought him into disagreement with most of his seniors in the university faculty. He continued his studies in this direction, however, without interruption until he had founded *The West German Magazine of History and Art,* the 'Society for the Advancement of Rhenish History' and had laid the foundations for his famous 'Deutsche Geschichte' in his first important work, 'Economic and Social Conditions in Germany during the Middle Ages,' in four volumes. All this was done during the years of 1880 to 1886 and while he was only a docent —an activity which bespoke the astonishing energy of the present professor. A year or two after the appearance of 'Social and Economic Conditions in the Middle Ages' Lamprecht was called to Marburg as ordentlicher professor, very much to the surprise of the wiseacres, who had opposed him at every turn at Bonn. In 1890, when only thirty-six years of age, he was made full professor of history at Leipzig, where he has been the directing spirit in the faculty of modern history ever since; his co-workers and assistants in this department number about a dozen and his students each semester average 350 to 400; in the historical seminars there are from ninety to one hundred men taking special training in *Kulturgeschichte.* These students come from all parts of the civilized world. It is not difficult then to understand what an immense influence Lamprecht is exercising on the present generation of historical students. Such is, briefly, the lifework of the man who has excited so much opposition in Germany. Let us examine more closely the main features of the new history and its methods.

Lamprecht divides all knowledge into two classes: the one dependent on mechanics, the other on psychology, *Naturwissenschaften* and *Geisteswissenschaften.* History is a science—a Geisteswissenschaft—dependent on psychology. It deals with the acts of men just as bot-

any, for example, deals with the manifestations of plant life. In neither case can we determine the nature of the inner, the motive-essence. The difference in the two sciences, however, consists in the fact that the historian deals with the activities of men and peoples long since passed beyond the reach of his personal knowledge. He relies upon more or less accurately attested depositions given by contemporaries or by the persons themselves, while the botanist, having the object of his investigations before him in most instances, is relieved of the task of rehabilitating extinct existences or species. The historian reconstructs the social and political characters of the past, masters the different intellectual movements, and then places each in its proper relative position, according to the most exacting methods of judgments and interpretations. The rules of accepting and rejecting evidence, of interpreting and classifying great historic events and tendencies which guide the historian in his reconstruction of the past entitle him to the rank of a scientist. The naturalist places a given animal in a certain class because of certain outward manifestations—the expression of the inner unknown forces; the historian places the historic character, whether statesman or peasant, in a certain class, by reason of the same kind of manifestations. In both instances the scientist is dealing with unknown quantities; but in both the outward activities are observed, interpreted, classified and made the basis of future judgments.

Following such a method of investigation one is prepared to appreciate, if not to accept, the second claim Lamprecht has put forward, viz., that history has not so much to do with great personages of the past as with the currents of thought, feeling or passion which produced those personages. He looks upon social, political and industrial leaders as exponents of popular or economic movements and deals with them as such in his writing. This relegates the kings and ministers of the present and past to quite insignificant positions and places the masses of the people in the forefront—a method not a little distasteful to the crowned heads of Europe.

Our new historian goes still further in his readjustment of historical method. Every people has gone through a certain more or less well-defined series of stages of evolution, *e. g.*, the Germans have passed through the following: symbolism, or the earlier and medieval history of the race; individualism, modern times to the French revolution; the age of the subjective soul-activity, or the nineteenth century to Wagner and Darwin, who introduce the present age of excitement and nervosity, if such a word may be used. It is the soul-life, *das Seelenleben*, of the people which determines the direction of national life, and this soul-activity is to be *understood* only as one fully comprehends the every-day life of the peasant, the artisan and the trader. This neces-

sitates a minute study of the hitherto neglected records of town and country life, the contracts, deeds, marriage bonds, parish lists, folk-lore and song, in fact everything down to the names of villages and the houses of the *Bauern*. Nothing has escaped Lamprecht's attention; and the results of twenty years of such investigation are recorded in his 'Deutsche Geschichte' (in six volumes) already mentioned. The 'common man,' who Alexander v. Humboldt had declared in 1809 could never be anything but a minute particle of the material of history, becomes with the Leipzig historian a guiding force in society, the very corner-stone of the building.

According to this method 'the making of history' which the politicians so often conceive to be their rôle in life is a very misleading term. History is not made, but it unfolds itself as a resultant of the thousand and one forces of which our leaders are but the humble exponents. The great influences which give a people their character and determine the direction of their development arise from climatic and geographical conditions, race antecedents and the reaction on these of economic forces, which forces are themselves in large measure the resultants of the above-mentioned conditions. Economic advantage and industrial aptitude determine the character of a people, not the will of leaders or leading classes.

To be sure this is not altogether a new view of history. Voltaire, suggestive in so many lines of thought, boldly proclaimed such to be the true historical method. Buckle spent twenty years in the attempt to elevate history to the rank of a science, and certainly succeeded in calling attention to the neglected influences in 'history-making'; but not in relegating governments to the positions of social machines, not in dethroning the long-worshipped heroes and martyrs of the past. Moreover, Buckle's work was in no way so intensive as that of the German *Kulturhistoriker,* and what Buckle attempted for English history, Karl Biedermann accomplished for Germany in his monumental 'History of German Civilization in the Eighteenth Century.' Biedermann was one of those liberal thinkers whose dream for the Vaterland was so rudely disturbed by the all-conquering Bismarck spirit in the early seventies. The influence of both Buckle and Biedermann was swallowed up by the idea- and hero-worship of Ranke and his followers. And this tendency was in full harmony with the prevailing political opinions. The same influence is found in England in the works of Freeman and Gardiner and Stubbs.

The appearance of the 'Deutsche Geschichte' was a challenge for opposition of which its author must have been conscious. German history writing, since 1860, as has been suggested, has been a constant imitation of the great Berlin professor, Ranke. And to understand

the *Kampf um die Kulturgeschichte* it is necessary first to review briefly the Ranke method.

Leopold von Ranke's first great service to accurate scholarship was his practical discovery of the Venetian relation. From this time on he was a most tireless student of European archives; his books are all most faithful interpretations of the contents of these store houses of history. From the time of the appearance of his 'Roman Popes' and the 'German History in the Time of the Reformation,' 1834 to 1847, a sort of ideology has prevailed in almost all historical writing not only in Europe, but in our own country. With Ranke great ideas not dissimilar to those of Plato's philosophical system furnished the *motif* according to which all his work was done. These ideas were the state, the church, the reformation, the counter reformation, etc. The individual had but to adjust himself to the greater almost God-given idea of the time; he was not the author of the idea or one of the makers of movements, as Lamprecht would have him. In truth Ranke's history deals almost exclusively with politics and political heroes, representatives of certain ideas. This idealism was a part of the prevailing philosophy, an application in history of Fichte and Hegel and Schelling in philosophy. Now the followers of Ranke, instead of adding to and broadening the Ranke method as times changed and new *Weltanschauungen* took the place of the older idealism, considered themselves fortunate if the world called them successful imitators and pupils. Great works they produced, indeed, such, for example, as Curtius' 'Greece,' Trietschke's 'Germany in the Nineteenth Century' and Mommsen's 'Roman History'; but they were all of essentially the same nature—page after page of accurate history bridged up on tiers of learned notes. A statement of Ranke or of Mommsen is capable of mathematical demonstration. Aside from those greater Rankianer, who are all dead except Mommsen, we have a whole brood of *Jungrankianer,* writing biographies, *Staatengeschichte* and theses on isolated ideas. These fill to-day the majority of German professor- and docentships; and history in their hands has reached a scientific accuracy never dreamed of by Gibbon or Niebuhr.

Looked at from one point of view, one would have expected these students and writers to endorse heartily Lamprecht's claim that history is a science. All their efforts, since Ranke's latter years at any rate, had been directed toward that goal; but the author of the new 'Deutsche Geschichte' took them off their feet by cutting asunder all connection between history and its supposed 'makers,' princes and heroes, by putting first and above all the great masses of the people and by making havoc with the Ranke tradition. Instead of seeking the sources of historical information in the greater or smaller European state archives, Lamprecht had diligently studied the Stadt and

Dorf records, the very store accounts of the people. What could have been more revolutionary? In addition to this, history embraces, according to the new comer, all phases of intellectual and physical activity, and not, as the Rankianer believe, only the political side of things. This was not only a sharp reflection on the older school, but a second very practical, if unspoken, declaration that the aristocratic portion of the country should occupy relatively only a few of the pages of history.

Still another cause for complaint of Lamprecht's 'history as a science' is to be found in the latter's approval of the work of the Rankianer as a basis for *Kulturgeschichte,* for a true *Weltgeschichte* which was declared to be a necessary result of the new method. The idea that Ranke and Mommsen had been *preparing* the way for still greater historians was distasteful enough to the Berlin professors—the wearers of the Ranke mantle. Another of Lamprecht's disagreeable claims is that a full and complete list of authorities may be omitted and that the historian's page need not always be securely underpinned with double columns of notes and references. The text itself should embrace the results of the works of individual scholars who have preceded him, should show that the author has compassed the whole field and garnered the fruits of others, but he is not necessarily required to give the names of all the sowers. 'Too many compilations of this kind we have already,' says the Leipzig professor.

Again, Lamprecht's history is based on Darwinism, *i. e.,* it views every element of our present culture world as a result of evolution. Now every follower of Ranke believes in the correctness of Darwin's principal conclusions, and a history which applied these conclusions would have met with their approval but for the fact that it appeared as a sort of criticism of themselves. Emerson's saying that we distrust our own best thoughts until another gives them expression might fitly apply here if he had but added 'but we are usually angered at the one who announces them if they prove popular.' Schopenhauer's protest against idealism, his violent destructiveness, seriously affected the *Weltanschauung* of Ranke historians; then came the Englishman's revolutionary teaching completely superseding the traditional German philosophy, but all to no effect so far as history-writing was concerned. Lamprecht believes the theory of evolution has ceased to be a theory, that it is really the basis of modern thought, and consequently he holds that history must be rewritten, if it is to meet the demands of the time. His 'Deutsche Geschichte' reestablishes the connection between history and philosophy.

A work of such revolutionary character must necessarily meet violent opposition rather than fair criticism. The question which the unbiased student of history asks is: Does the book satisfy the demands of history while answering the requirements of philosophy? Del-

brück, Lenz and Bülow, all of the strictest Ranke sect, answer this question in the negative, and in support of their position they have successfully shown that numerous errors of detail have been made, that in many instances Lamprecht has used the writings of his predecessors without making the customary acknowledgment. Errors of detail in such a work covering, as it does, two thousand years of German history, are to be expected, and they are, if not too serious, readily excusable. This seems to be the case with the 'Deutsche Geschichte' even if we accept all that the Berlin critics claim. The second objection, the use of the writings of his predecessors without making the usual acknowledgments, is not so easily explained away unless one admits Lamprecht's theory, referred to above, that a historical writing of any pretension should embody the best works of the past and interpret them to the reader in the forms of present-day thought, and that it is not incumbent on the historian to give his authority for everything he states. Admitting this, Lamprecht's book meets every requirement of historical criticism and at the same time advances history-writing a long step forward.

One thing is evident, the Rankianer have of late years carried their methods to great extremes, to such extremes that many American students have manifested a disposition to revolt. And their position in Germany is still more untenable. A new man and a new method were needed; Lamprecht met the demand. On the other hand, a better style, a more attractive form of history-writing has long been the prayer of the general public. No one denies that Lamprecht is master of a brilliant style; he is not surpassed in the use of idiomatic German by the celebrated v. Treitschke himself, perhaps the best stylist of the Ranke school.

On the whole, Lamprecht has done a notable work. He has gathered about him more students of history than any other teacher in Europe; he has called into serious question the prevailing methods of studying and writing history; he has given us a book which is exceedingly interesting, which does not seriously violate the rules of the best criticism; and finally, he has almost convinced us that history is a science.

PULSE AND RHYTHM.

By MARY HALLOCK,
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THE close connection between pulse and rhythm has been speculated upon since the fourth century before Christ. Herophile, Avicenna, Savonarola, Saxon, Fernel and Samuel Hafen-Refferus have successively conjectured that the rhythmic phenomenon of pulse is in some way responsible for our sense of 'beat.' The speculation was fascinating. It could not become convincing without the help of data capable of being furnished only by very recently invented instruments and by recently accumulated knowledge.

A sense of rhythm, probably due to instinct, is found well developed low down in the animal series.* This fact is significant when one considers that the theory usually advanced and accepted is that physical activities of a regularly recurrent nature have created this sense in man. The beat of the pestle used by primitive man to crush grain, the blows of the flail, the rhythm of the quern and the spinning wheel, the rock of the cradle, and in short the entire series of industries where a regular beat or reciprocal motion suggests alternate action have been put forward as the probable origin of the dance, musical and verbal rhythm, and at length of the beat of music.†

Tempting as is this theory which associates the origin of rhythm with the development of ordered human activity, a rhythmic sound, call or cry is first found coexistent with the first complete circulatory system, heart with valves and blood vessels. This first appears in the insect family and there too, in the saltoria of the orthoptera (commonly known as crickets, grasshoppers and locusts) appears this conjunction of hearing, ability to call or stridulate, a nervous system and valvular heart. The common existence of these phenomena does not prove that the beat of the rudimentary insect heart led to rhythm, but it suggests, at least, that this combination has been subjectively fruitful of recurrent sound as a form of sexual and probably of pleasurable activity.

Mr. S. H. Scudder has put down the songs of these little creatures in musical notation,‡ giving them after careful consideration the attribute of rhythm. Unfortunately the circulatory system of the insect world

* 'Descent of Man,' Darwin, D. Appleton & Co., p. 566.

† 'Rhythmus und Arbeit,' Karl Bücher, passim.

‡ 'The Songs of the Grasshoppers,' *Am. Nat.*, Vol. II., p. 113.

has scarcely been investigated. As a curiosity, yet as a possible venture, a parallelism may be suggested between the stridulations of a cricket, which have been counted as occurring at the rate of between two and three chirps per second* and the number of pulse waves peculiar to very active insects or one hundred and fifty closures of the heart valves in one minute.†

Inspecting in a very cursory manner the higher phylums of the animal kingdom, the authority of numerous investigators can be given for the perfect rhythmic quality of bird songs. The writer can vouch for it that the cackle of one guinea hen during an entire summer went with clock-like regularity at the rate of eighty-eight to ninety-two cackles per minute. The faster cackling being a laughably accurate sign of the growing excitement attendant on the laying of an egg, said by the owner to occur at about eleven o'clock every morning.

The scientific study of rhythm, so far as man is concerned, has been approached almost wholly from the side of its conjunction with literature. Looked at from that side, it is not strange that the testimony could never be mathematically exact and emphatic. The only data which are of sufficient accuracy to prove that the rhythmic phenomena of pulse first impressed on our consciousness that which can accurately be called rhythm, are to be found in the metronomic denotations of musical compositions. It is there and there only that the brain has been able systematically to externalize the rhythm most natural to it with a sense of method and order approximating instrumental exactitude and capable of an exact expression and measure in number. These furnish only a trace, but a trace sufficient when one keeps in mind the havoc that conscious intellect can always play with things strictly natural.

While making a bibliographical search for anything treating of this musical side of the subject, one suggestive title only was found. It was under 'pulse' in the Larousse Encyclopedia and covered the subject to a degree alarming to a new and anxious investigator. It 'Nouvelle methode facile et curieuse pour connaître le pouls par les notes de la musique.' (New method, easy and curious for gauging the pulse by musical notes.) François Nicolas Marquet, Nancy, 1747. When found, the quaint little book proved lamentably insufficient. In its time there was neither metronome nor sphygmograph.

In the introduction to this little treatise which in its day seems to have created quite a stir—'amateurs in search of novelties bought it for fun, and kept it by good taste,' M. Marquet naïvely tries to disarm his critics by saying that he already seemed to hear them object: 'it is certainly a very bizarre matter this learning to know the pulse by musical notes,' adding, 'one could answer them, it is not more strange

* '*Proc. Boston Soc. Nat. Hist.*, October 23, 1867.

† 'A Text-book of Entomology,' Packard, Macmillan, 1898, p. 401.

to paint the pulse with notes than to paint the sound of music with those same notes; to paint numbers with figures, and finally to paint words with letters.' In this way the good doctor confounds throughout the treatise the idea that music notes and measures could make a very good sign-board on which to denote exactly where a morbid pulse fails of being normal, and his discovery that a minute of his time was usually placed at the same rhythmic rate per minute as accompanies a normal pulse, which pulse, for want of a better chronometer than the long hand of a clock, he places at one beat per second.

This little work, imperfect as it is, and in spite of all its limitations, renders clear, tangible and visible the failure, already mentioned, made by those who thus far have occupied themselves with the question, to give consideration to the statistics furnished by musical compositions through their metronomic denotations. Even the ear aided by the metronome and the pulse recorded by the sphygmograph need to prove the influence of the latter on the former, the unconscious record made in musical composition of the recollection by the mind from an indefinite number of beats per second of a certain stated number, which repeats itself in one form of union after another by different composers at different periods and in different lands.

The material from which statistics can be drawn is so unlimited that, for want of space, two examples only will be considered, the first dealing with the metronomic markings of the Beethoven Sonatas and the second with popular music.

Out of forty-three metronomic markings, taken straight through from the beginning of the first volume of the Beethoven Sonatas—the four standard editions as a working basis—nineteen are set to a rhythm of seventy-two and seventy-six beats to a minute, a rate exactly that of the average normal, healthy, adult human pulse; a pulse given by the best authorities as lying between seventy and seventy-five pulsations in the same time. According to fuller statistics, the physical pulse, varied by the time of day and the effect of meals, ranges from a little below sixty to a little over eighty. Within this limit all the rhythmic markings of these sonatas lie. Three standing at fifty-six and fifty-eight beats per minute, contrary to expectation, belonging to fast movements undoubtedly marked slower on account of the difficulty the fingers would experience in performing the notes as fast as the imagination would direct. The average of the entire one hundred and forty-seven markings given by the four editors, Von Bülow, Steingräber, Köhler and Germer, was sixty-four and four tenths rhythmic beats per minute. The one sonata marked by Beethoven himself bearing the figures 69, 80, 92, 76, 72 for the different movements, Allegro, Vivace, Adagio, Largo, Allegro risoluto.

If with the eye fixed on the second-hand of a watch or a clock the long meter doxology be sung, every one of the equally accented notes entering simultaneously with the tick of each consecutive second, it will become at once apparent that the melody is delivered at a rhythmic rate of sixty beats to the minute. Should one in the same breath hum Yankee-doodle, sounding each of its accented notes, at the same rate, it will be found that these two melodies, standing at the extremes of the sublime and the ridiculous, the one in character slow, the other fast, the first combining the utmost dignity and breadth, the second ludicrously vapid and thoughtless, are both set to precisely the same length of rhythmic time by the clock. In the same manner the adagios, allegros, prestos of the great master's sonatas unfold to pretty much the same span of a passing moment. In his sonata 'Les Adieux,' op. 81, the adagio or slow movement and the allegro or fast movement are both set to one rhythmic unit to the second. The impression of slowness or rapidity in the music is due rather to the character of the context and the number of notes to be played in the divisions within the minute than to the actual clock time it takes to perform the rhythmic unit.

Seventeen letters were addressed to as many band-masters asking them for the 'beat' usually used in their conducting. The answers invariably brought 'from 64 to 72 rhythmic beats per minute,' that being probably the time to which countless soldiers had found it most convenient and agreeable to march. Those wishing to investigate on their own account will find it interesting to clutch at their pulse, whenever a whistling street boy passes, and even a jangling hotel piano might in the same connection have sometimes a 'reason for being.' More often than accident warrants, it will be found that these also 'with nature's heart in tune' were 'concerting harmonies.'

METRONOMIC MARKINGS PER RHYTHM OF THE DIFFERENT MOVEMENTS OF TWELVE BEETHOVEN SONATAS.

Sonata, Op. 2, No. 1.	Sonata, Op. 2, No. 3.	Sonata, Opus 13.	Sonata, Opus 22.	Sonata, Opus 26.	Sonata, Op. 27, No. 2.	Sonata, Op. 31, No. 2.	Sonata, Opus 53.	Sonata, Opus 57.	Sonata, Opus 78.	Sonata, Opus 79.	Sonata, Opus 106.
56	76	66	72	76	60	56	76	76	72	72	69
80	66	72	58	80	76	92	66	58	63	56	80
72	76	60	63	72	76	80	76	76	69	72	92
56	58	52	76	60							76
											72

The foregoing examples, although following the pulse in their exactness, are still for scientific purposes not quite what may be desired. The heart's action varies. So do musical tempi. Both are disturbed by the slightest exciting or nervous influences. Still the track, though faint at times, sometimes quite effaced by conscious effort, is there; corroborated through a hundred different channels. One distinguished psychologist* finds that a subject could repeat simple intervals without accent with greatest exactness when these intervals lay between 0.4 and 0.7 seconds. It takes but a simple problem in arithmetic to see that this agrees with from 75 to 86 rhythmic beats per minute, or the region of pulsation common to the human pulse. Another† on conducting a series of experiments on rhythm, 'the first and most important object of which was to determine what the mind did with a series of simple auditory impressions in which there was absolutely no change of intensity, pitch, quality or tone interval,' finds that the pulse seemed at times to impose a grouping in which the clicks coming nearest to the time of the heart beats were accented.

To Professor Bolton‡ must be given the credit of having successfully found the means by which rhythm can be permanently differentiated from time in music. He says this general principle, arrived at by the same experiments, may be stated: "The conception of a rhythm demands a perfectly regular sequence of impressions within the limits of one second and one hundredth of a second. When a longer interval was introduced into the series, the impressions coming between the long intervals fell together into a group but they did not form an organic unity. There was no pleasure in such a rhythm. Something seemed to be looked for in this longer interval which was wanting." Why?

No matter how slowly one sound follows another, time, as understood in music, can still be a characteristic of the sequence. A clock may strike this minute and not again for an hour, but time is still being measured. A rhythm, however, can be said to exist only when sounds succeed each other so as to fall within the same limited horizon of attention. This differentiation has not to this day been clearly made by authors of musical encyclopedias and dictionaries, they having been satisfied with considering rhythm as simply similar in music to meter in verse.

Bearing these statements in mind, it seems improbable that the mere physical activities and industries of primitive peoples, such as cradle-rocking, spinning and grinding should have been so constantly of one rhythm as to impress accidentally a beat of such uniform variation, extending within fifteen pulsations difference a minute

* 'The Psychology of Rhythm,' *Am. Journ. of Psychol.*, January, 1902.

† *American Journ. Psychol.*, Vol. VI., No. 2.

‡ *Ibid.*

(from 65 to 80) on nearly all musical compositions, nor must it be forgotten, as has been said before, that it is these compositions which furnish the only means by which the human brain could, thanks to the metronome, so accurately and sub-consciously give record to the rhythm most natural to it. This rhythm for physical as well as psychological reasons must, it is submitted, in all probability have been suggested, coordinated and regulated by the phenomenon of pulse. The first and patent objection to this theory will be that we have no conscious cognizance of the arterial beat within us. The objection is however fully met by the well-known law that, 'one unvarying action on the senses fails to give any perception whatever.' For familiar examples, we have no conscious sensory impressions from the whirling of the earth, the weight of the air or the weight of our bodies. Yet, inevitably, the recurrent arterial beat, must have left its record and impress on the unconscious and subliminal brain, guiding and determining the conscious and audible expressions. Nor is it without its supporting proof that where the insect's heart beat is 150 to the minute, the insect's chirp runs to the same speed; and where the human heart beat is 60 to 85 to the minute, human musical rhythm runs within the same limits.

Mr. Fiske says, in his 'Outlines of Cosmic Philosophy,' not only must all motions be rhythmical, but 'every rhythm, great or small, must end in some redistribution, be it general or local, of matter and motion.' It is not probable that a dainty rhythmic wave of color external in character would make its impression on the brain, and the latter in turn remain unaffected by a—relatively speaking—thumping cataract of a pulse impulse. Some disturbance of the brain tissue must occur from this vibration, reaching in course the very portion allotted to music. The basilar artery, the brain's basic artery, feeds the chorda tympani by a direct channel, whereas the rest of the cranial tract is fed by ramifications of its ramifications. The stronger surging is therefore directed against the auditory tract. It may be urged that in that case the brain would know but one rhythm. It might be so were it not that 'the whole cerebral and central nervous organism seems a happy adjustment of fixity of habit not too fixed, and susceptibility not too susceptible.'*

"Perception of time duration is always a process and never a state —for us to perceive five seconds, something must durate five seconds, for us to perceive a year some definite sensation would have to durate a year."†

On these principles, imagining a composer seated quietly at his desk in the act of composition, is it not feasible to suppose that sub-

* Herbert Nichols, *Journ. of Psychol.*, Vol. VI., p. 60.

† *Ibid.*

consciously to himself, and for want of a more intimately sympathetic conductor, a physical metronome was within him deflecting his rhythm to its standard? Contrary to the other arts, music has its birth and being entirely from within the human brain, and from within has been impressed a beat of far more rapid rate than the ictus of the recurrent industries already cited on its musical product. The suggestions all this calls forth are of course unlimited. To one we may give our fancy free rein. Mr. James Huneker in his exhaustive summing up of Chopin's music states that master's favorite metronome sign to be 88 to the minute. As 'people with considerable sensibility of mind and disposition have generally a quicker pulse than those with such mental qualification as resolution and steadiness of temper,' could one consider that the ailing Chopin's pulse helped his rhythmic tendency to 88, while the resolute steady Beethoven's was normal?

The arm of knowledge is long; it needs no yardstick with which to measure the stars. Can it feel the pulse of those who have long since crossed the boundaries that separate this world from the next?

THEORIES OF SLEEP.

By PERCY G. STILES,
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IT is not easy to define the condition of sleep in terms that will not admit of many exceptions. We readily recognize the states of rest and activity, but where the element of consciousness must be considered we are at once upon uncertain ground. If we think of sleep as an unconscious state, sharply contrasted with waking, we do well to limit our use of the word to the case of man and the most intelligent animals. Sleep in this sense is only to be associated with highly developed nervous systems and its final explanation is to be sought in events taking place in the brain.

Various writers upon the subject of sleep have turned their attention to quite different aspects of the matter. Some have undertaken to show why there is the need of sleep and why the tendency to sleep comes on at the close of each day. These writers have dealt with general or systemic causes. Others have concerned themselves with the cause of the unconscious—or dreaming—state in which the sleeper lies. They have endeavored to suggest intimate and local causes. Since the several theories are thus distinct in their application they are not necessarily mutually exclusive.

Broadly speaking we feel sure that the need of sleep follows from general or local fatigue. During waking hours the decomposition processes of the body doubtless rise above the life-long mean, and sooner or later there must be a compensatory fall below the average. The adaptation of the race to alternating light and darkness has made this rhythmic rise and fall to coincide with day and night—though less rigidly under the artificial conditions of civilized life than in more primitive times.

Fatigue at bottom is a chemical phenomenon, and so the theories of the first class are chemical. When a muscle has been stimulated until it exhibits the well-known signs of fatigue, there are two possible inferences—either this means an exhaustion of fuel substances or an accumulation of poisonous waste. Analogous views have been supported in regard to the chemical changes that lead to sleep. We have had an exhaustion theory advanced by Pflüger and an accumulation theory offered by Preyer.

Pflüger's theory has little experimental evidence in its favor. We know that a bloodless muscle may be subjected to a vacuum and made to part with its free oxygen, but that it is still capable of doing much work and of giving off carbon dioxide. In other words, oxidation may take place in the absence of free oxygen. Of course there is but one reasonable explanation, namely, that there is a store of the element in loose chemical combination. This store in the cells is spoken of as 'intra-molecular' oxygen, and its amount may be supposed to vary between rather wide limits. Pflüger pointed out that during the day, the katabolic processes being above the average, this hoard might be reduced until the lack of it should lead to the depression of functional activity and the suspension of consciousness characteristic of sleep.

Perhaps no one will maintain that this theory is adequate by itself. If there were nothing but intra-molecular oxygen to be considered, we should expect that a day of idleness would leave one fresh and bright at bed-time and that severe exercise for half a day might make a long sleep a pressing necessity. Pflüger's idea seems to explain more readily the sensation of being *tired* than that of being *sleepy*, which is so often quite independent of the other.

The alternative theory is to the effect that the waste-products of metabolism are not fully and promptly removed as they are formed during the day's activities, but gradually clog and poison the system until torpor is induced. The lactic acid produced in muscular contractions is held responsible for a great part of this toxic process. Acidity of the blood produces coma, and whatever reduces its normal alkalinity might be expected to favor sleep. Many objections to this theory suggest themselves. It does not explain why many people are at their best late in the day, nor why the onset of sleep is relatively sudden, nor why we are sleepy in the height of digestion when the blood is most alkaline. It is perhaps less easy to assail it if we suppose that the waste-products in question are not at large in the blood but have accumulated in certain cells, especially of the nervous system. In this case we need not assume a large quantity of these narcotic poisons, but only a peculiar distribution, and we can see why mental work is quite as fatiguing as physical work.

The transition from wakefulness to sleep seems rather abrupt, but is not instantaneous. Motor control is generally lost before sensation, and most people agree that of the avenues of communication with the world without, hearing is the last to be closed. This order of events is reversed in waking, when the alarm-clock or the unwelcome call is heard for an appreciable time before the eyes can be opened or a definite sense of one's situation realized. The sinking into sleep is

favored by the removal of all that may excite either the attention or the reflexes. Darkness, quiet, bodily comfort and mental serenity are therefore sought. Sleep may be prevented by any of the contrary conditions—light, noise, pain or anxiety. When it is necessary to contend against drowsiness, one instinctively seeks objects for attention or sensory stimulation, such as may be secured by taking a slightly uncomfortable position. Evidently sleep presupposes a release of the brain from many stimuli and may be warded off by seeing to it that no such release is granted. There is on record the case of an unfortunate boy who had no cutaneous sensibility, was blind in one eye and deaf in one ear. His mentality was of a low order. To cause him to sleep it was only necessary to cover the serviceable eye and ear for a few moments. Here the waking condition was clearly dependent on an unceasing flow of sensory impulses into the brain. A person of higher intelligence, similarly afflicted, would doubtless sleep much less readily, for trains of thought might keep him awake in default of external stimuli.

The approach of sleep is accompanied by distinct vascular changes. The blood stream is shifting its bed. A most imperious summons to sleep comes from the dryness of the eyes, the sign, probably, of a lessened blood-flow through the tear glands. At the same time the temperature of the skin rises, possibly excepting that of the extremities. There is evidence then of a dilatation of the cutaneous vessels as sleep comes on, and the final passage into unconsciousness is accompanied by a considerable further dilatation. These vascular changes have been nicely gauged by what is known as the plethysmographic method, where the subject lay with one hand and forearm fixed in a glass cylinder filled with water. An increase of blood in the arm displaced water from the cylinder and a delicate recording apparatus showed how this dilatation came on with sleep and passed off with waking. An account of such experiments, of more than technical interest, is that contributed by Dr. W. H. Howell to *The Journal of Experimental Medicine* (Vol. II.).

It is generally inferred that the cutaneous dilatation at once reduces the general blood-pressure and the quantity of blood flowing through the brain, by diverting a large share to the skin. The lowering of pressure has been demonstrated by Brush and Fayerweather; the fact that there is anemia of the brain during sleep has been established by direct observation. An English physiologist, Hill, has been led to believe that the dilatation of blood-vessels that relieves the brain in sleep is not limited to the skin, but shared by the arteries of the digestive tract. That this is so is difficult to prove, but it is suggestive that a heavy meal is followed by a long sleep in the case of the lower animals and often with us by a hard struggle with drowsiness.

Cerebral anemia may be merely a concomitant of sleep, but it has frequently been held to be its immediate cause, the cells having previously been fatigued and suffered a lowering of functional capacity which has made them increasingly susceptible to depressing influences. This is the basis of Howell's theory. He has suggested that the exhaustion of the vaso-motor center is what induces sleep. We know that this center is in tonic activity, sending out impulses which hold the blood-vessels in a state of constriction greater than is natural for them. This tonic activity can only mean constant metabolism in the cells of the center. Furthermore the center is subject to the play of afferent impulses from all parts of the body. It is reflexly spurred to action by every sensory impression through eye or ear. It is called to respond in an appropriate manner to every change of posture or other muscular movement. It does not escape the effects of psychic processes, emotional states. Nothing is more natural than to suppose that the nerve cells of the center become fatigued by this unceasing activity. After the hours that we habitually number in a period of waking it responds less and less readily to the demands made upon it. It begins to lose its grip, so to speak, on the superficial and perhaps the splanchnic vessels. The blood supply to the brain tends to become less and the pressure in its arteries to be reduced. The subjective consequence is drowsiness. If it is resisted by fixing the attention or by exercise, the center rallies temporarily under the spurring, contracting the vessels and turning the tide of blood back into the brain. But the anemia soon returns, and the drowsiness becomes more compelling. When the person lies down, a flood of sensory impulses that have been pouring in from the contracting muscles is suddenly checked. The eyes are closed and the stream of visual impulses ceases. With the withdrawal of this reflex stimulation and the acquiescence of the will the center relaxes still further its hold upon the cutaneous vessels, the blood-flow in the brain becomes more reduced, and unconsciousness comes on. During sleep the vaso-motor center is responsive to stimuli from without as the plethysmographic experiments show. A sufficient stimulus produces waking, and seems to operate by turning back into the brain a sufficient quantity of blood displaced from the contracting vessels of the skin. Such a stimulus must be a strong one in the first hour or two of sleep, but later a much weaker one will answer. Several physiologists have tested the depth of sleep at different hours of the night, judging of it by the height from which a weight must be dropped that the sound of its fall shall arouse the sleeper. All have agreed that the greatest depth of sleep is reached as early as the second hour. According to one writer it becomes steadily more shallow from that time until the end. Others have observed a second, minor deep-

ening toward morning. Many people will agree that their own sensations seem to imply such a second period of comparatively profound sleep.

What we call natural waking in the morning is usually due to some stimulus from without—light or sound—which would not have roused one from the deep sleep of midnight. But the stimulus may come from within, as from the state of certain organs or, curiously enough, from the previous resolution to wake at a certain time, which often operates with something of the compulsion of a hypnotic suggestion. Howell supposes that during sleep the nerve-cells of the vaso-motor center are gradually restored to prime condition and hour by hour become more irritable. So it is easier and easier as time passes to induce the vascular changes that involve waking. Moreover, the recuperated center resumes something of its normal tonic activity before consciousness returns, and so the final step is taken with none of that sense of violence that accompanies a sudden waking from sound sleep. The border-line is likely to be crossed and recrossed several times before the waking state is well established. When one is fairly roused mental activity and the pouring in of sensory impulses keep him from further napping.

Now what peculiar condition can be conceived to exist in the brain during the period of anemia and unconsciousness? What microscopical changes may be supposed to mark the transition from wakefulness to sleep? Oddly enough, the two hypotheses which are extant are quite opposite in character. The first, which has attracted the greater notice, is that of Duval. He has suggested that consciousness depends on the contact of cell-processes in the brain whereby effects are propagated from neurone to neurone. If sensory impulses are to alter consciousness, there must be a pathway for their passage. If a single synapse on the course of such a pathway is rendered impassable, the message from the sense-organ is lost from conscious life. If every sensory path is interrupted at any point between the periphery and the cortex, there must be insensibility as to the outside world and the state of the body. If all motor paths are likewise broken, there can be no voluntary action. If, in the third place, the association paths are also severed, there can be no synthetical processes of thought, no ideation. In short, the brain must lose its individuality by the breaking of connections between its structural elements. If we could suppose that every synapse in the central nervous system might be snapped, and impassable gaps opened between the cells wherever one had been wont to influence another, there must be an end of consciousness, for, in utter isolation, these cells could no longer combine their activities into one whole such as forms the physical basis of psychic

life. A much more local disruption of connection, limited perhaps to the cortex, might be sufficient to explain the subjective condition in sleep. At any rate, Duval's view is that the cortical cells are capable of retracting or extending their processes so as to sever and resume their relation with neighboring elements. Experimental evidence in support of this theory is naturally slight. Wiedersheim has described amœboid movements on the part of cells in the nervous system of a small transparent crab. Of course it is only in such lower forms that the living cells can readily be brought under the microscope. Duval himself suddenly beheaded dogs that were awake and others in anæsthesia and made histological preparations from the brains. He believed he could distinguish the sleeping brain by the more contracted and isolated appearance of its cells.

The second histological theory of sleep, which has been said to be quite opposed to the first, is that of the Italian neurologist, Lugaro. Both demand the capability of amœboid movement on the part of the cells. But while Duval supposes that in sleep the cells have broken their contacts, Lugaro supposes that they have made *new contacts* with great freedom. At first thought this view seems unreasonable. A multiplicity of contacts and added pathways in the brain might be supposed to imply a richer and keener consciousness. But this would be true only to a certain point. When the indiscriminate combination had gone a step further mental confusion might be expected, then fantastic associations and a meaningless mosaic of memories—practically a state of dreaming. Let the cells commingle their impulses still more freely and consciousness will be lost, for the diffusion of energy in the brain will result in a lessened intensity of flow in the principal channels. If each cell scatters its communications in every possible direction no definite effect in consciousness is to be looked for. According to Duval, the cells which are affected in sleep can not discharge; according to Lugaro, they may do so, but the resulting impulses are utterly dissipated in a maze of by-ways. Waking, according to Duval, is the resumption of intercourse among these cells; according to Lugaro, it is the restriction of intercourse to habitual and purposeful channels.

There is no reason why we may not be eclectic in regard to these two points of view. It may be that many paths are interrupted in sleep, while others are opened. In the hypnotic state it is clear that many paths are blocked, including those by which the will of the subject habitually asserts itself, while others, especially those making connections between the auditory and motor areas, transmit impulses with extraordinary efficiency. This condition is explicable if we suppose that certain synapses are broken, as Duval imagines, and that

the tide of nervous impulses pours with intensified energy through the narrowed outlets remaining—an idea borrowed from Lugaro. If we consider that a man is most thoroughly awake when his attention is most rigidly concentrated, when he is a 'man of one idea,' we shall perhaps incline toward Lugaro's conception of sleep, which is certainly as far as possible removed from this mental fixedness. Hypnosis is accompanied by cerebral congestion and natural sleep by anemia. There is accordingly a strong temptation to suppose that the cell-changes in the two states are opposite in their nature, that in hypnosis the retraction of the dendrites is characteristic and in natural sleep their extension. The sluggish condition of the mind under suggestion as compared with its fanciful flights in dreaming falls happily in line with this view. But such speculation is premature.

It was said at the outset that the several theories of sleep are not all mutually exclusive. It is possible to go beyond this statement, for we may assign a place to each of those mentioned without inconsistency. We may suppose in the first place that the alternation of day and night through the ages has impressed its rhythm upon the race, so that it is hard for the individual to break from the habitual course in which activity is associated with light and rest with darkness. In other words, the amount of the metabolism tends to keep above a mean for some hours and then to fall below it. The excess of destructive processes over those which are recuperative during the waking hours results in general and local fatigue, a condition into which may enter both the depletion of intra-molecular oxygen and the accumulation of toxic waste-products. While this progressive loss of condition affects the body as a whole, the nervous system is subject to its own peculiar drains. It is very probably the hard-worked vasomotor center which proves to be the vulnerable spot. With its release of the blood-vessels in certain areas from its reenforcing influence comes the cerebral anemia. Then, we may suppose, the nerve-cells become less active than in the brain which has its full supply of blood, that they cease to send impulses over the usual routes, either because gaps have opened or because such impulses as do arise are permitted to stray and be scattered, producing no effect in consciousness or one which is quite bizarre and meaningless.

Such an outline as this is a composite scheme in which the conditions emphasized by Pflüger and Preyer are given recognition as fundamental causes of sleep, Howell's idea is accepted as explaining well its onset, its varying depth and the awakening, while the pictures sketched by Duval and Lugaro are combined to represent the intimate state of the slumbering brain.

HERTZIAN WAVE WIRELESS TELEGRAPHY. IV.

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WE have to consider in the next place the arrangements of the receiving station and the various forms of receivers that have been devised for effecting telegraphy by Hertzian waves. Just as the transmitting station consists essentially of two parts, viz., a part for creating electrical oscillations and a part for throwing out or radiating electric waves, so the receiving station appliances may be divided into two portions; the function of one being to catch up a portion of the energy of the passing wave, and that of the other to make a record or intelligible signal in some manner in the form of an audible or visible sign.

Accordingly, there must be at the receiving station an arrangement called a receiving aerial, which in general takes the form of a long vertical wire or wires, similar in form to the transmitting aerial. There is, however, a distinct difference in the function of the transmitting aerial and the receiving aerial. The function of the first is effective radiation, and for this purpose the aerial must have associated with it a store of energy to be released as wave energy; but the function of the receiving aerial is to be the seat of an electromotive force which is created by the electric force and the magnetic force of the incident electric wave.

In tracing out the mode of operation of the transmitting aerial, it was pointed out that the electric waves emitted consisted of alternations of electric force in a direction which is perpendicular to the surface of the earth, and magnetic force parallel to the surface of the earth. These two quantities, the electric force and the magnetic force, are called the *wave vectors,* and they both lie in a plane perpendicular to the direction in which the wave is traveling and at right angles to one another, the electric force being perpendicular to the surface of the earth. In optical language, the wave sent out by the aerial would be called a plane polarized wave, the plane of polarization being parallel to the magnetic force. Hence, if at any point in the path of the wave we erect a vertical conductor, as the wave passes over it, it is cut transversely by the magnetic force of the wave and longitudinally by the electric force. Both of these operations result in the creation of an alternating electro-motive force in the receiving aerial wire.

As in all other cases of oscillatory motion, the principle of resonance may here be brought into play to increase immensely the amplitude of the current oscillations thereby set up in the receiving aerial. As already explained, any vertical insulated wire placed with its lower end near the earth has capacity with respect to the earth, and it has also inductance, the value of these factors depending on its shape and height. Accordingly, it has a natural electrical time-period of its own, and if the periodic electromotive impulses which are set up in it by the passage of the waves over it agree in period with its own natural time-period, then the amplitude of the current vibrations in it may become enormously greater than when there is a disagreement between these two periods. Before concluding these articles we shall return to this subject of electric resonance and syntony, and discuss it with reference to what is called the tuning of Hertzian wave stations. Meanwhile, it may be said that for the sake of obtaining, at any rate in an approximate degree, this coincidence of time-period, it is generally usual to make the receiving aerial as far as possible identical with the transmitting aerial. If the receiving aerial is not insulated, but is connected to the earth at its lower end through the primary coil of an oscillation transformer, we can still set up in it electrical oscillations by the impact on it of an electric wave of proper period; and if the oscillation transformer is properly constructed we can draw from its secondary circuit electric oscillations in a similar period.

One problem in connection with the design of a receiving aerial is that of increasing its effective length and capacity, so as to increase correspondingly the electromotive force or current oscillations in it. It is clear that if we put a number of receiving wires in parallel so that each one of them is operated upon by the wave separately, although we can increase in this way the magnitude of the alternating current which can be drawn off from the aerial, we cannot increase the electromotive force in it except by increasing the actual height of the wires. Unfortunately, there is a limit to the height of the receiving aerial. It has to be suspended, like the transmitting aerial, from a mast or tower, and the engineering problem of constructing such a permanent supporting structure higher than, say, two hundred feet, is a difficult one.

Since any one station has to send as well as receive, it is usual to make one and the same aerial wire or wires do double duty. It is switched over from the transmitting to the receiving apparatus, as required. This, however, is a concession to convenience and cost. In some respects it would be better to have two separate aerials at each station, the one of the best form for sending, and the other of the best form for receiving.

In Mr. Marconi's early arrangements, the so-called coherer or

sensitive wave-detecting appliance, to be described more in detail presently, was inserted between the base of the insulated receiving aerial and the earth, but it was subsequently found by him to be a great improvement to act upon the receiving device, not directly by the electromotive force set up in the aerial, but by the induced electromotive force of a special form of step-up oscillation transformer he calls a 'jigger,' the primary circuit of which was inserted in between the receiving aerial and the earth plate, and the secondary circuit was connected to the sensitive organ of the telegraphic receiving arrangements.* A suggestion to employ transformed oscillations in affecting a coherer, had also been described in a patent specification by Sir Oliver Lodge, in 1897, but the essence of success in the use of this device is not merely the employment of a transformer, but of a transformer constructed specially to transform electrical oscillations.

Turning then to the consideration of the relation existing between the transmitting and receiving aerials, we note that in their simplest form these consist of two similar tall rods of metal placed upright, with their feet in good connection with the earth at two places. We may think of them as two identical lightning conductors, well earthed at the bottom, and supported by non-conducting masts or towers. These rods must be in good connection with the earth, and therefore with it form, as it were, one conductor. If, as usual, these aerials are separated by the sea, the intermediate portion of this circuit is an electrolyte. The operations which take place when a signal is sent are as follows:

At the transmitting station, we set up in the transmitting aerial electric oscillations, of which the frequency may be of the order of a million, *i. e.,* the oscillations as long as they last are at the rate of a million a second. Each spark discharge at the transmitter results, however, only in the production of a train of a dozen or two oscillations, and these trains succeed each other at a rate depending upon the transmitting arrangements used. Each oscillation in the transmitting aerial is accompanied by the detachment from it of semi-loops of electric strain, as already explained. The alterations of electric strain directed perpendicularly to the earth, and of the associated magnetic force parallel to the earth, constitute an electric wave in the ether, just as the alternations of pressure and motion of air molecules constitute an air wave. Associated with these physical actions above

* The term 'jigger' is one of those slang terms which contrive to effect a permanent attachment to various arts and crafts. Similarly, the word 'booster' is now used for a step-up or voltage-raising transformer or dynamo, inserted in series with an electric supply main. The word 'boost' is a slang term signifying to raise or lift up. 'To give a real good boost' is an expression for lending a helping hand. The term 'jigger,' in the same manner, is an adaptation of seaman's term for hoisting tackle or lift.

ground, there is a propagation through the earth of electric action, which may consist in a motion or atomic exchange of electrons. Each change or movement of a semiloop of electric strain above ground has its equivalent below ground in inter-atomic exchanges or movements of the electrons, on which the ends of these semi-loops of electric strain terminate. The earth must play therefore a very important part in so-called 'wireless telegraphy,' and we might almost say the earth does as much as the ether in its production.

The function of the receiving aerial is to bring about a union between these two operations above and below ground. When the electric waves fall upon it, they give rise to electromotive force in the receiving aerial, and therefore produce oscillations in it which, in fact, are electric currents flowing into and out of the receiving aerial. We may say that the transmitting aerial, the receiving aerial and the earth form one gigantic Hertz oscillator. In one part of this system, electric oscillations of a certain period are set up by the discharge of a condenser and are propagated to the other part. In the earth, there is a propagation of electric oscillations; in the space above and between the aerials, there is a propagation of electric waves. The receiving aerial *feels* therefore what is happening at the distant aerial and can be made to record it.*

We have next to consider the question of the wave detecting devices which enable us to appreciate and record the impact of a wave or wave train against the aerial. At the very outset it will be necessary to coin a new word to apply generally to these appliances. Most readers are probably familiar with the term 'coherer,' which was applied by Sir Oliver Lodge, in the first instance, to an electric wave-detecting device of one particular kind, viz., that in which a metal point was lightly pressed against another metal surface and caused to stick to it when an electric wave fell upon it. As our knowledge increased, it was found that there were many cases in which the effect of the electric radiation was to cause a severance and not a coherence, and hence such clumsy phrases as 'anticoherer' and 'self-decohering coherer' have come into use. Moreover, we have now many kinds of electric wave detectors based on quite different physical principles. At the risk of incurring reprobation for adding to scientific nomenclature, the author ventures to think that the time has arrived when a simple and inclusive term will be found useful to describe all the devices, whatever their nature, which are employed for detecting the presence of an electric wave. For this purpose the term ***kumascope,*** from the Greek κυμα (a wave), is suggested. The scientific study of waves has already been called

* The 'earth' itself probably only conducts electrolytically. All such materials as sand, clay, chalk, etc., and most surface soils are fairly good insulators when very dry, but conduct in virtue of moisture present in them.

kumatology, and in view of our familiarity with such terms as *microscope, electroscope* and *hygroscope,* there does not seem to be any objection to enlarging our vocabulary by calling a wave-detecting appliance a *kumascope.* We are then able to look at the subject broadly and to classify kumascopes of different kinds.

We may, in the first place, arrange them according to the principle on which they act. Thus, we may have electric, magnetic, thermal, chemical and physiological operations involved; and finally, we may divide them into those which are self-restoring, in the sense that after the passage or action of a wave upon them they return to their original sensitive condition; and those which are non-restoring, in that they must be subjected to some treatment to bring them back again to a condition in which they are fit to respond again to the action of a wave.

We have no space to refer to the whole of the steps of discovery which led up to the invention of all the various forms of the modern electric kumascope or wave detector. Suffice it to say that the researches of Hertz in 1887 threw a flood of light upon many previously obscure phenomena, and enabled us to see that an electric spark, and especially an oscillatory spark, creates a disturbance in the ether, which has a resemblance in nature to the expanding ripples produced by a stone hurled into water. Scientific investigation then returned with fresh interest to previously incomprehensible effects, and a new meaning was read into many old observations. Again and again it had been noticed that loose metallic contacts, loose aggregations of metallic filings or fragments, had a mysterious way of altering their conductivity under the action of electric sparks, lightning discharges and high electromotive forces.

As far back as 1852, Mr. Varley had noticed that masses of powdered metals had a very small conductivity, which increased in a remarkable way during thunderstorms;* and in 1866, C. and S. A. Varley patented a device for protecting telegraphic instruments from lightning, which consisted of a small box of powdered carbon in which were buried two nearly touching metal points, and they stated that 'powdered conducting matter offers a great resistance to a current of moderate tension, but offers but little resistance to currents of high tension.'†

We then pass over a long interval and find that the next published account of similar observations was due to Professor T. Calzecchi-Onesti, who described in an Italian journal, *Il Nuovo Cimento* (see Vol. 16, p. 58, and Vol. 17, p. 38), in 1884 and 1885 his observations on the decrease in resistance of metal powders when the spark from an

* *The Electrician,* Vol. XL., p. 86 (Leader).

† *British Patent Specification,* C. and S. A. Varley, No. 165, 1866.

induction coil was sent through them.* These observations did not attract much attention until Professor E. Branly, of Paris, in 1890 and 1891, repeated them on an extended scale and with great variations, making the important observation that an electric spark *at a distance* had a similar effect in increasing the conductivity of metallic powders.† Branly, however, noticed that in some cases of conductors in powder, such as the peroxide of lead or antimony, the effect of the spark was to cause a decrease of conductivity.

To Professor E. Branly unquestionably belongs the honor of giving to science a new weapon in the shape of a tube containing metallic filings or powder rather loosely packed between metal plugs, and of showing that when the pressure on the powder was adjusted such a tube may be a conductor of very high resistance, but that the electrical conductivity is enormously increased if an electric spark is made in its neighborhood. He also proved that the same effect occurred in the case of two slightly oxidized steel or copper wires laid across one another with light pressure, and that this loose or imperfect contact was extraordinarily sensitive to an electric spark, dropping in resistance from thousands of ohms to a few ohms when a spark was made many yards away.

It is curious to notice how long some important researches take to become generally known. Branly's work did not attract much attention in England until 1892, when Dr. Dawson Turner described his own repetition of Branly's experiments with the metallic filings tube, at a meeting of the British Association in Edinburgh. In the discussion which followed, Professor George Forbes made an important remark. He asked whether it was possible that the decrease in resistance could be brought about by Hertz waves.‡

This question shows that even in 1892 the idea that the effect of the spark on the Branly tube was really due to Hertzian waves was only just beginning to arise. The following year, however, Mr. W. B. Croft repeated Branly's experiment with copper filings before the Physical Society of London, and entitled his short paper 'Electric Radiation on Copper Filings.'§ He exhibited a tube containing copper filings loosely held between two copper plugs and joined in series with a galvanometer and cell. The effect of an electric spark at a distance, in causing increase of conductivity, was shown, and the return of the tube to its non-conducting state when tapped was also noticed.

* See also *Journal de Physique*, Vol. V., p. 573, 1886.

† See *Comptes Rendus*, Vol. CXI., p. 785; Vol. CXII., p. 112, 1891; or *La Lumière Electrique*, Vol. XL., pp. 301, 506, 1891; or *The Electrician*, Vol. XXVII., 1891, pp. 221, 448.

‡ See *The Electrician*, Vol. XXIX., 1892, pp. 397 and 432.

§ Mr. W. B. Croft, *Proc. Phys. Soc.*, Vol. XII., p. 421. Report of meeting on October 27, 1893.

In the discussion which followed the reading of this paper, Professor Minchin described the effects of electric radiation on his impulsion cells. He followed up this by reading a paper to the Physical Society on November 24, 1893, on the action of Hertzian radiation on films containing metallic powders, and expressed the opinion that the change in resistance of the Branly tube was due to electric radiation.*

Thus, at the end of 1893, a few physicists clearly recognized that a new means had been given to us for detecting those invisible ether waves, the chief properties of which Hertz had unraveled with surpassing skill six years before, by means of a detecter consisting of a ring of wire having a small spark gap in it.

In June, 1894, Sir Oliver Lodge delivered a discourse at the Royal Institution, entitled 'The Work of Hertz,' and at this lecture use was made of the Branly tube as a Hertz wave detecter. The chief object of the lecture was to describe the properties of Hertzian waves and their reflection, absorption and transmission, and many brilliant quasi-optical experiments were exhibited. Although a Branly tube, or imperfect metallic contact, then named by him a *coherer,* was employed by Sir Oliver Lodge to detect an electric wave generated in another room, there was no mention in this lecture of any use of the instrument for telegraphic purposes.†

As we are here concerned only with the applications in telegraphy, we shall not spend any more time discussing the purely scientific work done with laboratory forms of this wave detector.

Without attempting to touch the very delicate question as to the precise point at which laboratory research passed into technical application, we shall briefly describe the forms of kumascope which have been devised with special reference to Hertzian wave telegraphic work. A very exact classification is at present impossible, but we may say that telegraphic kumascopes may be roughly divided into six classes. The first class includes all those that depend for their action on the 'coherer principle' or the reduction of the resistance of a metallic microphone by the action of electromotive force. As they depend upon an imperfect contact, they may be called *contact kumascopes.* This class is furthermore subdivided into the self-restoring and the non-self-restoring varieties. The second class comprises the *magnetic kumascopes*

* See Professor Minchin, *Proc. Phys. Soc.*, November 24, 1893; or *The Electrician*, Vol. XXXII., 1893, p. 123. See also Professor Minchin, *Phil. Mag.*, January, 1894, Vol. 37, p. 90, 'On the Action of Electromagnetic Radiation on Films containing Metallic Powders.'

† This lecture was afterwards published as a book, the first edition bearing the same title as the lecture, *viz.*, 'The Work of Hertz and Some of his Successors.' In the second edition, published in 1898, an appendix was added (p. 59) containing 'The History of the Coherer Principle,' and the original title of the work had prefixed to it, 'Signalling without Wires.'

which depend upon the action of an electrical oscillation as a magnetizing or demagnetizing agency. The third class comprises the *electrolytic responders,* in which the action of electric oscillations either promotes or destroys the results of electrolysis. The fourth class consists of the *electrothermal detectors,* in which the power of an electrical oscillation as a high frequency electric current to heat a conductor is utilized. The fifth class comprises the *electromagnetic* or *electrodynamic* instruments, which are virtually very sensitive alternating current ammeters, adapted for immensely high frequency. The sixth class must be made to contain all those which cannot be well fitted at present into any of the others, such as the sensitive responder of Schäfer, the action of which is not very clearly made out.

We may proceed briefly to describe the construction of the principal forms of kumascope coming under the above headings. In the first place, let us consider those which are commonly called the 'coherers' or, as the writer prefers to call them, the *contact kumascopes.* The simplest of these is the crossed needle or single contact, which originated with Professor E. Branly.* The pressure of the point of a steel needle against an aluminium plate was subsequently found by Sir Oliver Lodge to be a very sensitive arrangement when so adjusted that a single cell sends little or no current through the contact.† When an electric wave passes over it, good conducting contact ensues. The point is, in fact, welded to the plate, and can only be detached by giving the plate or needle a light shock or vibration. A variation of the above form is a pair of crossed needles, one resting on the other.

Professor Branly found, in 1891, that if a pair of slightly oxidized copper wires rest across one another the contact resistance may fall from 8,000 to 7 ohms by the impact of an electric wave. He has recently devised a tripod arrangement, in which a light metal stool with three slightly oxidized legs stands on a polished plate of steel. The contact points must be oxidized, but not too heavily, and the stool makes a bad electrical contact until a wave falls upon it.† The decoherence is effected by giving the stool a tilt by means of an electromagnet.

These single or multiple point kumascopes labor under the disadvantage that only a very small current can be passed through the variable contact when used as a relay arrangement, without welding them together so much that a considerable mechanical shock is required to break the contact and reset the trap.

* See *The Electrician,* Vol. XXVII., 1891, p. 222. E. Branly, 'Variations of Conductivity under Electrical Influence.'

† See *The Electrician,* Vol. XL., p. 90. Sir Oliver Lodge, 'The History of the Coherer Principle.'

‡ See Professor E. Branly, 'A Sensitive Coherer,' *Comptes Rendus,* Vol. CXXXIV., p. 1187, 1902; or *Science Abstracts,* Vol. V., p. 852, 1902.

The logical development of the single contact is therefore the infinite number of contacts existing in the tube of metallic filings, which has been the form of kumascope most used for many years. In its typical form it consists of a tube of insulating material with metallic plugs at each end, and between them a mass of metallic powder, filings, borings, granules or small spheres, lightly touching one another. Imperfect contact must be arranged by light pressure, and in the majority of cases the resistance is very large until an electric wave falls upon the tube, when it drops suddenly to a small value and remains there until the tube is given a slight shake or the granules disturbed in any way, when the resistance suddenly rises again. This type of responder is a non-restoring kumascope, and requires the continual operation of some external agency to keep it in a condition in which it is receptive or sensitive to electric waves.

Much discussion and considerable research have taken place in connection with the action and improvement of these metallic powder kumascopes. As regards materials, the magnetic metals, nickel, iron and cobalt, in the order named, appear to give the best results. The noble metals, gold, silver and platinum, are too sensitive, and the very oxidizable metals too insensitive, for telegraphic work, but an admixture may be advantageously made.

Omitting the intermediate developments of invention, it may be said that Mr. Marconi was the first to recognize that to secure great sensibility in an electric wave detecter of this type the following conditions must be fulfilled: An exceedingly small mass of metallic filings must be placed in a very narrow gap between two plugs, the whole being contained in a vessel which is wholly or partly exhausted of its air. Mr. Marconi devoted himself with great success to the development of this instrument, and in a very short time succeeded in transforming it from an uncertain laboratory appliance, capable of yielding results only in very skilled hands, into an instrument certain and simple in its operations as an ordinary telegraphic relay. He did this, partly by reducing its size, and partly by a most judicious selection of materials for its construction. As made at present, the Marconi metallic filings tube consists of a small glass tube, the interior diameter of which is not much more than one eighth of an inch, which has in it two silver plugs which are beveled off obliquely. These are placed opposite to each other so as to form a wedge-shaped gap, about a millimeter in width at the bottom and two, or at most three, millimeters in width at the top (see Fig. 1). The silver plugs exactly fill the aperture of the tube, and are connected to platinum wires sealed through the glass. The tube has a lateral glass tube fused into it, by which the exhaustion is made, which is afterwards sealed off, and this tube projects on the side of the wider portion of the gap between the

silver plugs. The sensitive material consists of a mixture of metallic filings, five per cent. silver and ninety-five per cent. nickel, being carefully mixed and sifted to a certain standard fineness. In the manufacture of these tubes, great care is taken to make them as far as possible absolutely identical. Each tube when finished is exhausted, but not to a very high vacuum. The tube so finished is attached to a bone holder, by which it can be held in a horizontal position. The object of beveling off the plugs in the Marconi tube is to enable the sensitiveness of the tube to be varied by turning it round, so that the small quantity of filings lie in between a wider or narrower part of the gap.*

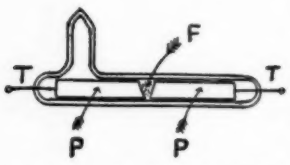

FIG. 1. MARCONI SENSITIVE TUBE OR METALLIC FILINGS KUMASCOPE. *PP*, silver plugs; *TT*, platinum wires; *F*, nickel and silver filings.

Other ways of adjusting the quantity of the filings to the width of the gap have been devised. Sometimes one of the plugs is made movable. In other cases, such as the tubes devised by M. Blondel and Sir Oliver Lodge, there is a pocket in the glass receptacle to hold square filings, from which more or less can be shaken into the gap.

An interesting question, which we have not time to discuss in full, is the cause of the initial coherence of the metallic filings in a Branly tube. It does not seem to be a simple welding action due to heat, and it certainly takes place with a difference of potential, which is very far indeed below that which we know is required to produce a spark. On the other hand, it seems to be proved that in a Branly tube, when acted upon by electric waves, chains of metallic particles are produced. The effect is not peculiar to electric waves. It can be accomplished by the application of any high electromotive force. Thus, Branly found that coherence may be produced by the application of an electromotive force of twenty or thirty volts, operating through a very high water resistance and thus precluding the passage of any but an excessively small current. Again, the coherence seems to take place in some cases when metallic particles are immersed in a liquid, or even in a solid, insulator. Professor Branly has therefore preferred to speak of masses of metallic granules as *radio-conductors,* and Professor Bose has divided substances into positive and negative, according as the operation of electromotive force is to increase the coherence of the particles or to decrease it.

It has been asserted that for every particular Branly tube, there is a critical electromotive force, in the neighborhood of two or three volts, which causes the tube to break down and pass instantly from a non-

* This device of making the inter-electrode gap in a tubular filings coherer wedge-shaped has been patented again and again by various inventors. See German patent No. 116,113, Class 21a, 1900. It has also been claimed by M. Tissot.

conductive to a conductive condition, and that this critical electromotive force may become a measure of the utility of the tube for telegraphic purposes. Thus, C. Kinsley (*Physical Review*, Vol. XII., p. 177, 1901) has made measurements of this supposed critical potential for different 'coherers,' and subsequently tested the same as receivers at a wireless telegraph station of the U. S. A. Signal Corps. The average of twenty-four experiments gave in one case 2.2 volts as the breaking down potential of one of these coherers or Branly tubes, 3.8 volts for a second and 5.5 volts for the third. These same instruments, tested as telegraphic kumascopes, showed that the first of the three was most sensitive.

On the other hand, W. H. Eccles (*Electrician*, Vol. XLVII., pp. 682 and 715, 1901) has made experiments with Marconi nickel-silver sensitive tubes, using a liquid potentiometer made with copper sulphate, to apply the potential so that infinitesimal spark contacts might be avoided and the changes in potential made without any abruptness. He states that if the coherer tube is continuously tapped, say at the rate of fifty vibrations per second, whilst at the same time an increasing potential is applied to its terminals and the current passing through it measured on a galvanometer, there is no abrupt change in current at any point. He found that when the current and voltage were plotted against each other, a regular curve was obtained, which after a time becomes linear. A decided change occurs in the conductivity of the mass of metallic filings when treated in this manner at voltages lower than the critical voltage obtained by previous methods. He ascertained that there was a complete correspondence between the sensitiveness of the tubes used as telegraphic instruments and the form of the characteristic curve of current and voltage drawn by the above described method.

In the same manner, K. E. Guthe and A. Trowbridge (*Physical Review*, Vol. II., p. 22, 1900) investigated the action of a simple ball coherer formed of half a dozen steel, lead or phosphor-bronze balls in slight contact. They measured the current i passing through the series under the action of a difference of potential v between the ends, and found a relation which could be expressed in the form

$$v = V\,(1 - e^{ki})$$

where V and k are constants.

The current through this ball coherer is therefore a logarithmic function of the potential difference between its ends, of the form

$$i = a \log\,(v - V)$$

and exhibits no discontinuity.

The inference was drawn that the 'resistance' is due to films of

water adhering to the metallic particles through which electrolytic action occurs.

A good metallic filings tube for use as a receiver in Hertzian wave telegraphy should exhibit a constancy of action and should cohere and decohere, to use the common terms, sharply, at the smallest possible tap. It should not have a current passed through it by the external cell of more than a fraction of a milliampere, or else it becomes wounded and unsensitive.

The investigations which have already taken place seem to show pretty clearly that the agency causing the masses of filings to pass from a non-conductive to a conductive condition is electromotive force, and that therefore it is the electromotive force set up in the aerial by the incident waves which is the effective agent in causing the change in the metallic filings tube, when this is used as a telegraphic kumascope. This transformation of the tube from a non-conductor to a conductor is made to act as a circuit-closer, completing the circuit, by means of which a single cell of a local battery is made to send current through an ordinary telegraph relay, and so by the aid of a second battery operate a telegraphic printer or recorder of any kind. Hence, it is clear that after one impact, the metallic filings tube has to be brought back to its non-conductive condition, and this may be achieved in several ways. (1) By the administration of carefully regulated taps or shocks or by rotating the tube on its axis; (2) by the aid of an alternating current; (3) in those cases where filings of magnetic metals are employed, by magnetism.

The decoherence by taps was discovered by Branly,* and Popoff, following the example of Sir Oliver Lodge, employed an electric bell arrangement for this purpose.†

Mr. Marconi, in his original receiving instruments, placed an electromagnet under the coherer tube with a vibrating armature like an electric bell.‡ This armature carries a small hammer or tapper, which, when set in action, hits the tube on the under side, and various adjusting screws are arranged for regulating exactly the force and amplitude of the blows. This tapper is actuated by the same current as the Morse printer, or other telegraphic recorder, so that when the signal is received and the metallic filings tube passes into the conductive condition and closes the relay circuit, this latter in turn closes the circuit of the Morse printer or other recorder, and, at the same time, a current passes through the electromagnet of the tapper and the tube is tapped back. This sequence of operations requires a certain

* See *The Electrician*, Vol. XXVII., 1891, p. 448.

† Journal of *The Russian Physical and Chemical Society*, Vol. XXVIII.; division of physics, Part I., January, 1896.

‡ See Brit. Patent Specification, No. 12,039, June 2, 1896.

time which limits the speed of receiving. The tapper has to be so arranged that it is possible to receive and to record not only the *dot* but a *dash* on the Morse system. The *dash* is really a series of closely adjacent dots, which run together in virtue of the inertia and inductance of the different parts of the whole receiving apparatus. The adjustment has so to be made that, whilst the *dash* is being recorded and a continuous tapping is kept up, yet, nevertheless, the continued electromotive force in the aerial, due to the continually arriving trains of waves, is able to act against the tapping and to keep the filings in the tube in the conductive condition. Hence, the successful operation of the arrangement requires attention to a number of adjustments, but these are not more difficult, or even as difficult, as those involved in the use of many telegraphic receivers employed in ordinary telegraphy with wires.

Mr. Marconi also introduced devices for preventing the sparks at the contacts of the electromagnetic hammer from directly affecting the tube, and also to prevent the electric oscillations which are set up in the aerial from being partly shunted through other circuits than that of the sensitive tube. We pass on to notice the remaining devices for restoring the metallic filings tube to a condition of sensitiveness or receptiveness.

A method for doing this by alternating currents is due to Mr. S. G. Brown.* The pole pieces of the coherer tube are made of iron, and they are enveloped in magnetizing coils traversed by an alternating electric current. Between these pole pieces is placed a small quantity of nickel or iron filings, and under the action of the electromotive force, due to an electric wave acting on them, may be made to cohere in the usual fashion; but the moment that the wave ceases, the alternating magnetism of the electrodes causes the filings to drop apart or decohere. In place of the alternating current, Mr. Brown finds that a revolving permanent magnet can be used to produce the alternating magnetization of the pole pieces of the sensitive tube or coherer.

The third method of causing the decoherence of the filings is that due to T. Tommasina. He found that when a Branly tube is made with filings of a magnetic metal, such as iron, nickel and cobalt, the decoherence of the filings can be produced by means of an electromagnet placed in a suitable position under the tube.† The explanation of this fact seems to be that, when an electric wave falls upon the tube or when any other source of electromotive force acts upon it, chains of metallic particles are formed, stretching from one electrode

* British Patent Specification, No. 19,710 of 1899.

† *Comptes Rendus*, Vol. CXXVIII., p. 1225, 1889; *Science Abstracts*, Vol. II., p. 521.

to the other. Tommasina contends that he has proved the existence of these chains of particles by experiments made with iron filings; and R. Malagoli,* in referring to Tommasina's assertion, states that it can be witnessed in the case of brass filings placed between two plates of metal and immersed in vaseline oil, when a difference of potential is made between the plates.

T. Sundorph† says he has confirmed Tommasina's discovery of the formation of these chains of metallic particles in the coherer. The filings do not all cling together, but certain chains are formed which afford a conducting path for the current subsequently passed through the coherer from an external source. Accordingly, Tommasina's method of causing decoherence in the case of filings of magnetic metals is to pull them apart by an external magnetic field; and he stated that decoherence can be effected more easily and regularly in this way than by tapping. Whilst on this point, it may be mentioned that C. Tissot‡ says that he has found that the sensitiveness of a coherer formed of nickel and iron filings can be increased by placing it in the magnetic field, the lines of which are parallel to the axis of the tube. According to MM. A. Blondel and G. Dobkevitch, this is merely the result of an increased coherence of the particles.

(*To be continued.*)

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* *Il Nuovo Cimento*, Vol. X., p. 279, 1899.

† *Wied. Ann.*, Vol. LXVIII., p. 594, 1899; *Science Abstracts*, Vol. II., p. 757.

‡ *Comptes Rendus*, Vol. CXXX., p. 902, 1900; *Science Abstracts*, Vol. III., p. 615.

MOSQUITOES AND SUGGESTIONS FOR THEIR EXTERMINATION.*

By WILLIAM LYMAN UNDERWOOD,
LECTURER IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

THE statement has been frequently made of late that there is no more reason why we should suffer from mosquitoes than there is that we should allow rats and mice to continually annoy us, and this statement is in a measure true. Rats and mice are to a great extent effectively held in check; for we have become accustomed to them and their habits, and we know how to deal with them. Were it not for the fact that a constant warfare is being waged against them, they would soon overrun our houses and make life unbearable.

In order to fight the mosquitoes successfully it is important that every one should take an interest in the popular uprising against this insect pest. And now that it is known that, besides being a nuisance, mosquitoes may be a menace to the health of the community, it is equally necessary that every one should become familiar with all that pertains to their life history so that the war against them may be successfully and intelligently carried on. Notwithstanding all that has been written on the subject of mosquitoes, during the last year or two, the majority of people still know but little about them.

It is the purpose of this article to state, in as simple a manner as possible, the facts that are now known regarding mosquitoes and how to deal with these pests, and it is hoped that this information may help to secure a more general cooperation in the work of mosquito extermination.

Few people realize that there are a great many different kinds of mosquitoes. Some three hundred species have already been described, and here in the United States we have about fifty species, belonging to nine different genera. The most common of these genera in the northern states are *Anopheles,* the malarial, and *Culex,* the ordinary, mosquito. Of the former there are two species and of the latter at least fifteen.

Only these two genera and the methods for their extermination will be especially considered, and as these methods may also be successfully applied to the other kinds of mosquitoes, no detailed description of the others need be given.

* Illustrated with photographs from life by the author. The article and the photographs are copyrighted.

It is commonly and quite naturally thought that mosquitoes breed in wet grass, as they are often seen to rise from it in clouds when disturbed, particularly in the early morning and evening. They have not bred there, however, but have merely sought the shelter of the grass where they can be protected from the wind. The moisture of the dew upon the grass also furnishes an attraction for them and they always prefer damp rather than dry places.

Another popular theory is that mosquitoes will breed *only* in foul or stagnant water. This is also a mistaken idea though they often do breed in such water, not because it is impure or stagnant, however, but because these places are usually quiet and here the female can deposit her eggs undisturbed.

It is commonly supposed that mosquitoes do not breed in salt water, but the recent 'Mosquito Investigations' of Professor John B. Smith, of New Jersey, which were published in the New Jersey Agricultural College Experiment Station Report of November, 1902, show that the larvæ of *Culex sollicitans,* the 'Salt marsh mosquito,' not only prefer salt or brackish water, but are seldom found in pools where the water is strictly fresh, and, contrary to the usual custom, this mosquito lays its eggs upon the soil of marsh or meadow land. There the eggs remain until the advent of an unusually high tide. Then after a few hours when the water has covered them, the infant larvæ make their appearance.

It is very generally believed that mosquitoes bite but once and then die. This is sometimes so; but, unless they are killed in the act of biting, they usually live to bite again. The female mosquito (for it is only the female that attacks human beings) bites many times. It is owing to this fact that *Anopheles* is able to convey the germs of malarial fever from person to person. When biting any one who is afflicted with malaria, the insect draws in with the blood the germs of the disease, which it afterwards carries on into the blood of another victim. The vast majority of mosquitoes never get human blood for food. In its absence they live upon the blood of birds and other animals, and when these are not to be found, upon the juices of young and tender plants.

It is not known just how long mosquitoes can live, but their average life is much longer than is ordinarily supposed. Thousands of them live through winter hibernating or asleep in dark places in barns or house cellars. In sparsely settled localities, where they can not find such places for shelter, they live through the winter in hollow trees, in caves and holes under upturned trees; and, even though the temperature may fall far below freezing, they are not winter-killed, but on the approach of warm weather become active again. Mosqui-

toes are frequently seen flying about in the woods before the snow has wholly left the ground.

Mosquitoes can not develop or come to maturity without water in which to live during the first weeks of their 'wiggler' existence.

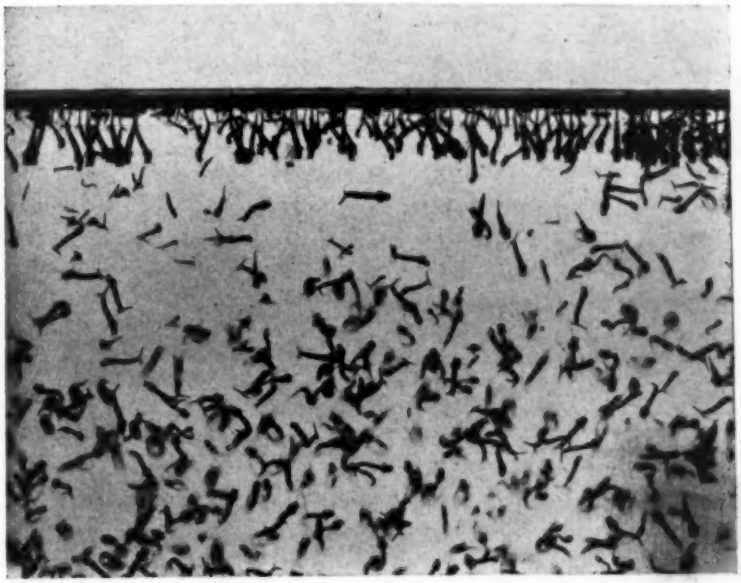


FIG. 1. MOSQUITO 'WIGGLERS'—LARVÆ AND PUPÆ—IN THE WATER. Life size.

A mosquito's life is divided into four stages—the egg, the larva, the pupa and the adult insect. In the larval and pupal stages, mosquitoes are more commonly known as 'wigglers' (see Fig. 1). Both

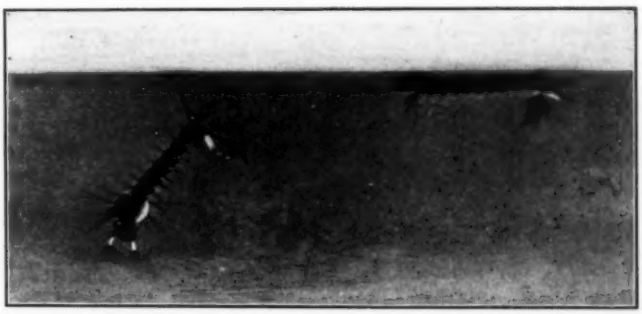


FIG. 2. MOSQUITO 'WIGGLERS' (LARVÆ) IN THE WATER. *Anopheles* LARVA TO THE RIGHT, *Culex* LARVA TO THE LEFT. Three times larger than life.

Anopheles, the malarial, and *Culex,* the common, mosquito larvæ are present in this picture. Mosquito 'wigglers' may frequently be found in rain-water barrels in as large numbers as are seen in this photograph. The female mosquito lays from one hundred and fifty to four

hundred eggs upon the surface of some quiet water, and in a day or two these eggs develop into the larval or second stage (see Fig. 2).

It will be noticed that *Culex* hangs with its head down, and from its tail upward to the surface of the water extends a small tube. Through this tube it breathes. *Anopheles* rests just beneath and parallel to the surface of the water, and its breathing tube is much shorter than that of *Culex*. These resting positions are quite different, and each is characteristic of its kind. Except when disturbed, *Anopheles* is generally to be found at the surface, breathing and feeding in this position. *Culex*, on the other hand, comes to the surface only occasionally to breathe. It stays below the water for the greater part of the time, and is often found feeding from the bottom.

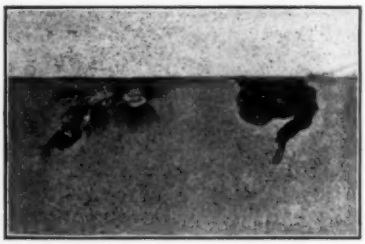


FIG. 3. A PUPA, THE THIRD STAGE IN A MOSQUITO'S LIFE. Three times as large as life.

At the end of a few days the larvæ change into the pupal or third stage (see Fig. 3). To the left is seen the larval skin out of which this pupa has just come. The difference between *Culex* and *Anopheles* in this, the final stage of 'wiggler' existence, is very slight. Both now

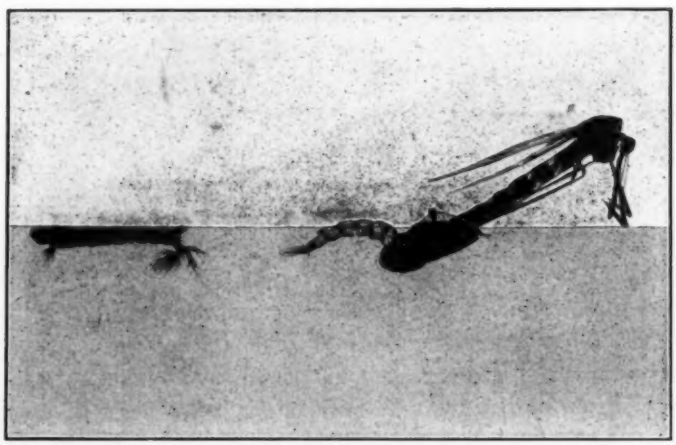


FIG. 4. AN ADULT MOSQUITO (*Anopheles*) TRANSFORMING FROM A PUPA AND COMING OUT OF THE WATER. Three times as large as life.

live at the surface of the water, and they breathe through two funnel-shaped tubes situated one on each side of the thorax, or 'head.' Unless disturbed, they remain motionless in this position at the surface until the time comes when, as adult mosquitoes, they leave the water (see Fig. 4). This is the critical period of a mosquito's life; for, should

the surface of the water be disturbed at this time, the insect would be upset and drowned. It takes about seven minutes from the time when the skin along the back of the pupa begins to split until the full-grown mosquito comes forth and in a few minutes is ready to fly away. A mosquito never grows any larger after this change.

The length of time required to pass from the egg to the adult insect varies from ten days to three weeks, according to the temperature. Warm weather hastens their development, while low temperature checks it. The 'wigglers' of some species of mosquitoes live through the coldest weather of our northern winters unharmed, ready, when the first warm days of spring have come, to complete their natural changes.

Mosquitoes' eggs are so very small that ordinarily they remain unnoticed, but nearly every one who lives in the country is familiar with the little 'wigglers' that are often seen squirming up and down in rain-water barrels. Few people know that these little fellows are connected in any way with mosquitoes, but it is a very easy matter to prove that they are. Let any one who doubts this fact dip up a few in a glass jar or tumbler and place them in the house, where they can be frequently looked at. Seeing is believing; and after a full-grown mosquito has once been seen to come forth from a pupa (which is the last stage of the 'wiggler'), there can not any longer be any question as to what these 'wigglers' really are.

Most of the mosquitoes that annoy us are bred near by, often, though unknown to us, in our own dooryards. Any water that is accessible to mosquitoes and whose surface is undisturbed by winds or rapid currents furnishes a breeding-place for them, and 'wigglers' may often be found in water standing in old tin cans or bottles, in rain-water barrels, in pools in the rocks, in roof or street gutters that are not properly drained, in cesspools or in catch-basins, in fact, in any place that will hold water for a week or two, no matter how small the quantity, even if only a few teaspoonfuls.

Since we know that without water mosquitoes in their first stages can not exist, it naturally follows that all standing water should be done away with or treated in such a manner that 'wigglers' can not live in it nor mosquitoes get to it to lay their eggs. To this end all cans, bottles and every discarded utensil that will hold water should be removed. All stagnant pools, where it is possible to do so, should be drained or filled up. Cisterns, rain-water barrels and cesspools should be screened or otherwise covered to prevent the adult insects from having access to them. Where it is not practicable to fill, drain, or screen the places that are suitable for mosquitoes to breed in, the surface of the water may be covered with kerosene oil. This oil, when spread over the water, prevents the 'wigglers' from getting air

when they come to the surface to breathe, and so kills them (see Figs. 5 and 6).

In Fig. 5 a 'wiggler' is seen trying to get air, vainly thrusting its breathing tube up into the film of kerosene.

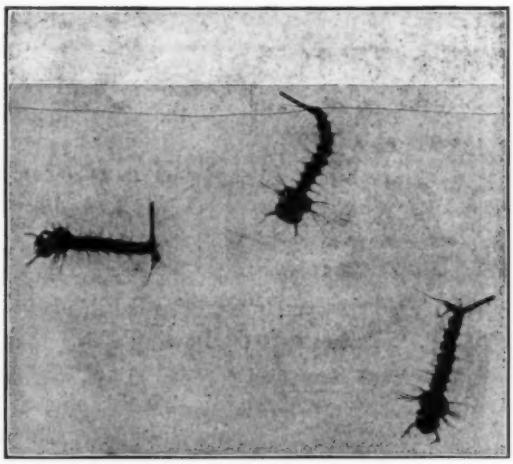


FIG. 5. THREE TIMES LARGER THAN LIFE.

In Fig. 6 the upper 'wiggler' is grasping its breathing tube in its mouth, apparently trying to pull off the small particles of kerosene

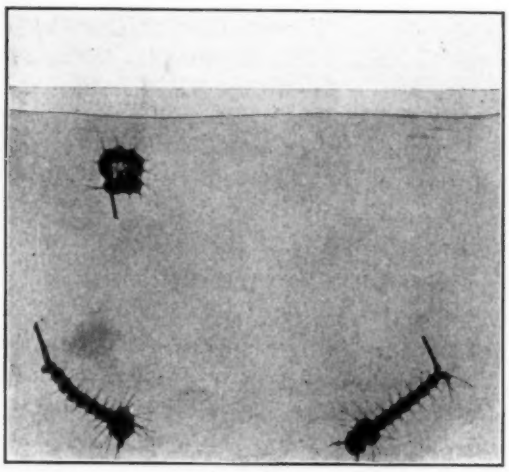


FIG. 6. THREE TIMES LARGER THAN LIFE.

with which the tube has been clogged. The 'wigglers' upon the bottom have been suffocated and have given up the fight.

An ounce (two tablespoonfuls) of kerosene will spread over fifteen square feet of water surface, forming a film thick enough to kill all

the 'wigglers' that are beneath it. Kerosene of a cheap quality, known as high test light fuel oil, is preferable for this purpose. It can usually be bought at eight cents a gallon. If oil of this quality is not available, ordinary kerosene will answer the purpose. It should be applied as often as once in two weeks, for by that time the previous applica-

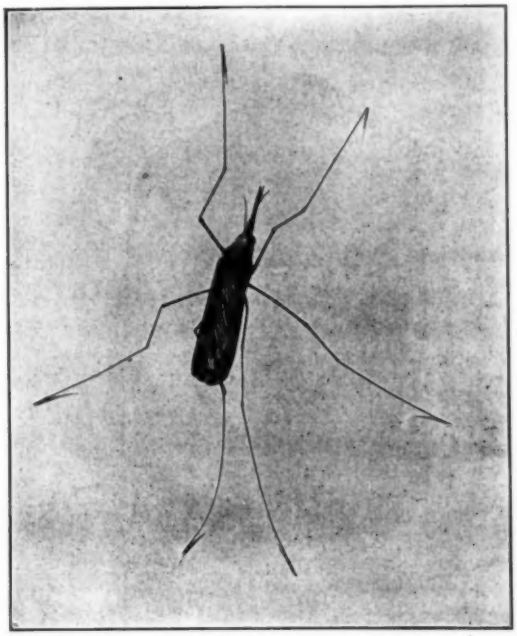


FIG. 7. *Anopheles punctipennis* (FEMALE). Three times larger than life.

tion will have evaporated. A sufficient quantity should be used, in the proportions named, to cover completely any place that may need treatment.

Any one who is ill with malaria or yellow fever should be carefully protected from mosquitoes, for, should a person be bitten by an *Anopheles,* the malarial mosquito or *Stegomyia fasciata,* the yellow fever mosquito, at this time, there would be great danger that the insects might fly away and bite some one else and thus spread these diseases. Screens for both doors and windows form the best protection against mosquitoes at all times; but it often happens that the insects get into our houses, even though they are thoroughly screened, generally through some door or window that has been left open by mistake, or they may gain an entrance by coming down an unused chimney if the flue is allowed to remain open during the summer time. A house or a room may be cleared of mosquitoes by burning pyrethrum powder and allowing the smoke, which is not at all offensive to most people, thoroughly

to fill the room that is under treatment. This smoke kills or so stupefies the insects that they will not bite. Pyrethrum powder is a preparation of the plant *Pyrethrum roseum,* and is sometimes sold as Persian Insect Powder or Dalmation Powder; it can be bought at any drug store for about thirty-five cents a pound. It is a very fine, light powder; and an ounce of it will go a long way, making a large volume of smoke. A pyrethrum smudge or smoke may be started by covering a live coal, taken from the kitchen stove, with the powder, first placing the coal upon a small shovel, so that it may be moved about conveniently without danger of setting anything on fire. The pyrethrum will

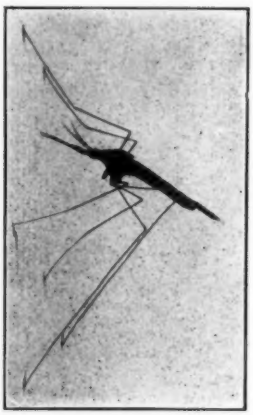


FIG. 8. PROFILE OF *Anopheles punctipennis* (FEMALE). Three times larger than life. Showing the characteristic resting position of this mosquito.

FIG. 9. PROFILE OF A *Culex* MOSQUITO (FEMALE). Three times larger than life.

quickly begin to smoulder and give off a dense smoke. All that is now necessary is to add from time to time a pinch of the powder as occasion requires, merely keeping the smouldering ashes covered so that they will give off a smoke. People are frequently annoyed and sometimes driven into their houses on summer evenings by the persistent attacks of mosquitoes. On such occasions, pyrethrum powder can often be used to advantage; and the smoke from a small quantity of the powder kept smouldering upon the piazza will drive away most, if not all, of the pests, thus making it possible to enjoy an evening out doors in comfort, when otherwise life would be unbearable except behind the protection of screens.

The *Anopheles,* or malarial mosquitoes, though not very common (see Figs. 7 and 8), are breeding quite abundantly in many parts of this country; and by referring to the accompanying photographs, particularly the ones in profile, it will be seen that there is quite a difference between the malarial and the common, or *Culex,* mosquitoes.

They may easily be distinguished from the common or *Culex* family of mosquitoes by the spots upon their wings, and also by the position which they take when at rest (see Fig. 8).

Notice the angle at which the insect shown in Fig. 8 stands out from the wall. Compare this with Fig. 9. It will also be seen that the proboscis, or 'stinger,' and the body of *Anopheles* form a straight line, while the *Culex* is rather humpbacked. The other *Anopheles, maculipennis,* does not stand out from the wall at quite such an angle as does *punctipennis;* but like the latter its proboscis and body form a straight line, and the angle formed by the insect when at rest is much greater than that of the *Culex.*

FIG. 10. PROFILE OF A MALE *Culex* MOSQUITO. Three times larger than life.

Notice how different is the resting position of the mosquito in Fig. 9 from that of *Anopheles* in Fig. 8.

The male mosquito (see Fig. 10) never bites. He may be easily distinguished by his large and feathered antennæ and palpi, which are very much more prominent than those of the female.

There is another mosquito, *Stegomyia fasciata,* which in form and habits closely resembles *Culex,* in which genus, until quite recently, it was classed. *Stegomyia fasciata* is the yellow fever mosquito, and it only inhabits the warmer portions of this country. It is common in most of our southern states and is seldom seen north of the Carolinas. It is easily distinguished from other mosquitoes by the conspicuous silvery white stripes upon its thorax and abdomen, and by the white bands upon its legs.

Fortunately for mankind, nature herself provides many energetic workers who are constantly doing their part towards holding in check these insect pests. Foremost among these natural enemies are many of the insectivorous birds, which daily destroy many thousands of mosquitoes. The swallows, the fly-catchers, the night hawks and the whip-poor-wills, all are insect exterminators, whose good work in this connection is seldom taken into account. The bat is also an efficient mosquito hunter; so too are the dragon flies which frequent the shores of ponds and pools where mosquitoes breed.

Besides these enemies of the adult mosquito, which may properly be called their 'foes of the air,' mosquitoes have other adversaries which destroy them in their early stages. These may be termed their 'foes of the water.'

It often happens that we can find no 'wigglers' in small ponds in which we would naturally expect to find mosquitoes breeding. In

such ponds the presence of fish may account for the absence of mosquitoes. Their larvæ furnish food for many species of our smaller fishes, and by them myriads of mosquitoes are annually destroyed. Goldfish are particularly fond of mosquito 'wigglers,' and the pair of fish in the illustration (see Fig. 11) were seen to eat ninety-eight 'wigglers' in four minutes. Goldfish will live and multiply in almost any small and shallow pond in this vicinity, where the water is warm. They are perfectly hardy and will thrive just as well and perhaps better in stagnant water than they will in fresh.

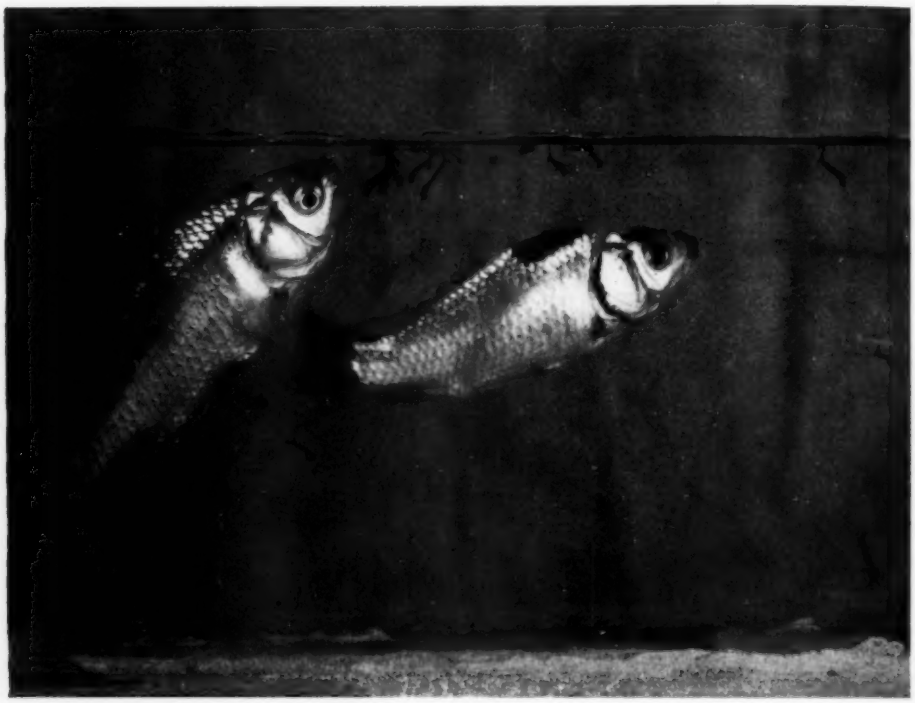


FIG. 11. GOLDFISH EATING MOSQUITO LARVÆ. Life size These two fish were seen to eat ninety-eight 'wigglers' in four minutes. They always fed upon mosquito larvæ when they could get them in preference to prepared goldfish food.

The 'top minnow,' the wach, the sunfish or 'pumpkin seed' and even the sluggish horn pout all play an important part in reducing the numbers of mosquito 'wigglers.' Besides the fishes, there are other 'foes of the water' that prey upon mosquito larvæ. Many of the predatory water bugs feed upon them. Professor J. B. Smith, in the report previously referred to, says that "among these predatory insects which abound in shallow permanent bodies of water wherever there is vegetation, the water boatman (*Corisa* and *Notonecta*), the water striders or 'skate bugs' (Hydrobatidæ) and the water scorpions (Ne-

pidæ, Belostomatidæ) deserve mention.'' He also speaks of the 'water tiger,' the larva of the large water beetle (*Dytiscus*), and tells of its ability to clear *Culex* larvæ from pools of water.

In this connection a brief description of a newly discovered mosquito,* to which has been given the name *Eucorethra underwoodi*, should be of interest, since it has been found that their larvæ devour the wigglers of other mosquitoes, and unlike other mosquitoes, the adult female insect does not bite. As the proboscis of this insect is so formed that it can not puncture the skin, it should not perhaps be called a true mosquito, though it has been classed as one, since it belongs to the family Culicidæ.

The larvæ of this insect were found by the author on January 27, 1903, in the Maine woods in the eastern section of Penobscot County, and were discovered in a spring of water from which a crew of lumber-

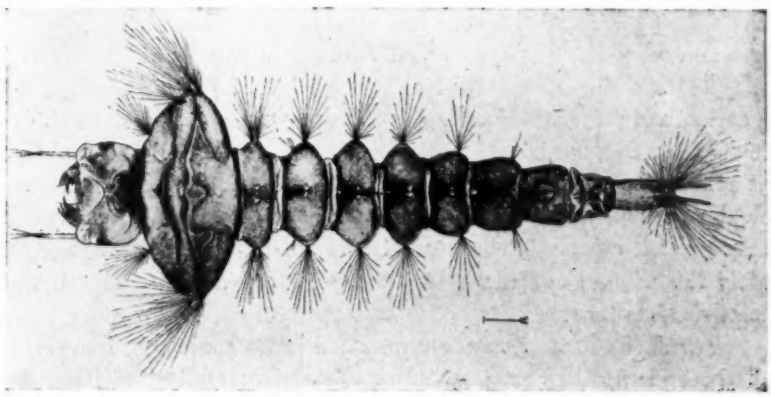


FIG. 12. LARVA *Eucorethra underwoodi*. DORSAL VIEW.

men were getting their water supply. A few days later, other larvæ of the same species were found in a similar spring about eight miles distant, though in this case, as the spring was not in use, its surface was covered with a coating of ice an inch thick. The temperature of the water at the bottom (it was about two feet deep) was 42° F.

At first sight this larva would be taken for an *Anopheles* of extraordinary size, as it is of the same general shape, and when the water was cleared of ice, it lay just beneath and parallel to the surface, breathing through a short respiratory siphon, as is characteristic of the larvæ of *Anopheles*. In this spring a barrel had been sunk and in the fifty gallons, or thereabouts, of water which it contained there were twenty-five larvæ. They were all of about the same size—12 to 14 mm. long

* Under the title 'A New Mosquito' a description of this mosquito appeared in *Science*, August 7, New Series, Vol. XVIII., No. 449.

—and almost black in color. All were secured and taken into camp for further investigation.

Close observation of the larvæ showed that besides being much larger (12–14 mm. long instead of 5–7 mm.) they differed in many other particulars from the larvæ of *Anopheles* (see Fig. 12). In proportion to the rest of its body, its head is larger than the head of *Anopheles*. It does not turn its head upside down when feeding as does *Anopheles*. Its mandibles are strikingly large and powerful and are prominently toothed. It lacks the frontal tufts or brushes which are conspicuously present in *Anopheles*, and its antennæ, which extend directly forward parallel with the sides of the head, are much longer and more slender, and are tipped each with three hairs of equal size. The thorax is broadly elliptical and is much wider in comparison with its abdominal segments than is the thorax of *Anopheles*. The sides of the thorax and the abdominal segments bear fanshaped tufts of hairs, not plumosed as in *Anopheles*. The tufts on the last segments, both dorsal and ventral (see Fig. 13), are more profuse in *Eucorethra* than in *Anopheles*, especially the ventral tuft which in *Eucorethra* occupies nearly the whole segment. Only two anal papillæ are present, while *Anopheles* has four.

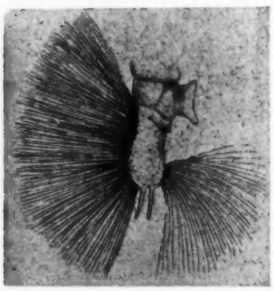


FIG. 13. LAST SEGMENT OF LARVA PROFILE.

A few days before the author returned to Boston, several larvæ died and three changed to pupæ. The pupa resembles that of *Culex* (see Fig. 14) rather than of *Anopheles* and its respiratory siphons are of the same shape as those of *Culex*. When stretched out at full length, the pupa measures ten mm.

On reaching home, the new wigglers, eighteen in number, were put into a quart jar which was placed near a window where it would receive the sunlight for two hours each morning. The temperature of the water now averaged about 70° F., and with this change the larvæ developed a new trait—they began to eat each other up. The act was witnessed on several occasions. The larva would grasp its adver-

FIG. 14. PUPA *Eucorethra underwoodi*. ORIGINAL DRAWING.

sary just forward of the respiratory siphon with its powerful mouth parts, and working the tail in first it would gradually swallow its victim, shaking it now and then as a terrier would shake a rat.

After losing many of the insects in this way, those that remained were separated, and each individual was placed in a small bottle by itself. Eventually, I succeeded in rearing a number of

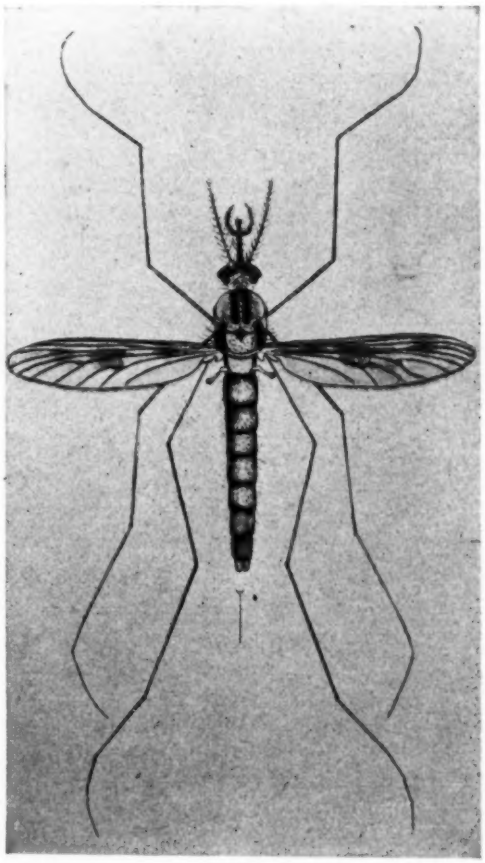


FIG. 15. *Eucorethra underwoodi*. COQUILLETT MS. ORIGINAL DRAWING.

males and females. The pupal stage of this insect varies from five days and nine hours to six days and ten hours. The adult (see Fig. 15) resembles *Anopheles* in having maculated or spotted wings, but is much larger and measures eleven millimeters in length. Its mouth parts, however, are not adapted for biting. A full description of the imago is soon to be recorded by Mr. D. W. Coquillett, of the National Museum, by whom the name above mentioned was given.

During a visit to Maine in June, a large number of larvæ of *Eucorethra* were taken from the spring where the barrel had been sunk. It was noticeable that larvæ of other kinds of mosquitoes were absent, although the adults were very numerous in the immediate vicinity.

The absence of other mosquito larvæ was accounted for when later it was discovered that the larvæ of *Eucorethra* fed upon the larvæ of other mosquitoes, eating them apparently with great relish. On several occasions fourteen *Eucorethra* larvæ ate, during the night, sixty *Culex* larvæ out of the seventy that had been placed in the water with them. When eating the larvæ of mosquitoes smaller than themselves, the victim is caught, shaken violently a few times, and swallowed in a few seconds in very much the same way that a pickerel would catch and swallow a smaller fish.

As yet no experiments have been made to see if this new species will devour the larvæ of *Anopheles* as readily as they will those of *Culex*. Whether or not this species will thrive in the climate of southern New England is as yet uncertain, but experiments are now being carried on to determine this point.

Although myriads of mosquitoes are destroyed by the natural enemies which have been mentioned, *man should* be the most destructive foe of these insects. There is no doubt that the mosquito pest may be very largely abated by the employment of scientific methods for causing its destruction in the early stages of its development.

While it is the duty of boards of health to recognize mosquitoes as active agencies for the dissemination of certain diseases and to take such measures as are possible for their extermination, the work can never be effectively done until the people of each community are fully informed in regard to the life history of the mosquito so that all may cooperate intelligently to secure its destruction.

SHORTER ARTICLES AND CORRESPONDENCE.

THE ASCENDING OBELISK OF THE MONTAGNE PELÉE.

THE extraordinary shaft of rock (lava) shown in the illustration now transfixes the newly-constructed cone of Pelée, and towers above it upward of 800 feet, giving to the volcano a height of 5,020 feet, instead of 4,250 (or 4,400) feet, which it had prior to the eruption of May 8, 1902. This unique structure which, on May 31 of this year, rose still 180 feet higher, is being and has been pushed up bodily, the lava solidifying before leaving the interior of the volcano. During the four days immediately preceding June 17, as determined by M. Guinoiseau, a member of the French Scientific Commission in Martinique, the lift or ascent was nearly 21 feet, but at an earlier day the movement was much more rapid. The obelisk, which meas-

OBELISK OF PELÉE. (Photograph by Angelo Heilprin, from the crater-rim of Pelée, June 13, 1903 (elevation, 4,100 feet).

ures 300–350 feet across at the base is slightly curved in the direction of Saint Pierre; the eastern face is smooth and grooved, showing well the marks of attrition against the encasing wall of rock which lined its channel of exit. On the west and southwest it is 'cavernous' and slaggy, having the impress of successive eruptions which have blown its parts asunder. On the night of June 12, immediately preceding my ascent, the southwest base was intensely luminous, shining out bright red with the lava that was being forced into it. A few days later, a thin vapor pennant was seen to issue from the absolute apex. Basal eruptions were taking place almost continuously.

ANGELO HEILPRIN.

PROFESSOR SHALER ON ANIMAL INTELLIGENCE.

TO THE EDITOR: Permit me to call your attention to an article by Professor N. S. Shaler in the July issue of *Harper's Monthly* under the caption 'Plant and Animal Intelligence.' This article contains so many glaring inaccuracies and misinterpretations of the views of Huxley, the monistic philosophers and those whom he terms 'men of the extreme Darwinian school' that in the interest of scientific truth—of which your journal has always been such a valuable exponent—some action on your part to correct the evil effect of these errors would be both timely and consistent. Now, I am not posing as a champion of monistic philosophy, but the public should not be misled with respect to what monism really means, nor should the broad-minded Huxley, the enemy of dogma, whether in science or religion, be held responsible for views not only foreign to his beliefs, but incompatible with his habits of thought.

Professor Shaler asserts that Huxley was the originator of the theory of animal automatism. One is tempted to believe that the learned professor has had no time to peruse Huxley's monograph on the subject, but has jumped at the conclusion that the title signifies a belief in that theory in its narrowest sense. The great name of Descartes, the real originator of the theory, is not even mentioned, and Professor Shaler seems to be ignorant of the fact that Huxley's interesting monograph is merely a critical analysis of Descartes's thesis, leading to the inevitable conclusion that the great seventeenth century philosopher's views on the subject were untenable, although in part justified by his marvelously prophetic insight into the truths of modern psychology and physiology.

The following extracts from Huxley's monograph show very clearly his thought on these subjects:

> But though I do not think that Descartes' hypothesis can be positively refuted, I am not disposed to accept it. The doctrine of continuity is too well established for it to be permissible to me to suppose that any complex natural phenomenon comes into existence suddenly, and without being preceded by simpler modifications; and very strong arguments would be needed to prove that such complex phenomena as those of consciousness, first make their appearance in man. . . . We know, further, that the lower animals possess, though less developed, that part of the brain which we have every reason to believe to be the organ of consciousness in man; and as, in other cases, function and organ are proportional, so we have a right to conclude it is with the brain; and that the brutes, though they may not possess our intensity of consciousness, and though, from the absence of language, they can have no trains of thoughts, but only trains of feelings, yet have a consciousness which, more or less distinctly, foreshadows our own.

It is true that Huxley, in another part of his essay, offers the postulate that man, and other higher organisms, are *conscious automata*, but this is very different from believing, as Professor Shaler asserts he did, 'that mind was a peculiarity of man, the lower animals being essentially automata, all their apparent intelligence being due to mere reflex action essentially comparable with mechanical movements such

as those of sensitive instruments—with no intelligence whatever in the action.'

Now, while the word automaton, in the literal sense, may be offensive as applied to man, coupled with the word 'conscious' it merely signifies a negation of the doctrine of free will or uncaused action. In other words, Huxley suggests that the state of consciousness preceding any so-called voluntary act is merely a part of the mechanism of that act, and not its cause, the cause being found in immediate external stimuli and molecular conditions, the result of the accumulated effects of more remote external stimuli incident during both individual and ancestral existence, and forming links in a long chain of causation which is finally lost in the infinite and absolute cause of all things.

Professor Shaler laboriously seeks to prove by Huxley's own familiar arguments the analogy between the psychic life of animals and that of man. It is really amusing to find Huxley, the author of 'Man's Place in Nature' and always a believer in the continuity of organic life, credited with doctrines actually subversive of his most cherished theories.

The philosophers of the extreme 'Darwinian' and monistic schools would be astonished and shocked, I am sure, to learn that they have committed philosophical 'hari kari' by regarding an elephant as an automaton. Surely the formation of species by the almost inconceivably slow and gradual process described by Darwin is incompatible with any theory calling for the sudden appearance of conscious man. Such a theory might be held more consistently by De Vries or others who question the validity of Darwin's generalizations and ask us to believe in the sudden 'mutation' of species.

One is loath to believe Professor Shaler serious in his statement that the monists have sought to establish their conception of the universe by exploiting a distinctly dualistic theory. Ernst Haeckel, who may be cited as a type of the extreme monistic school, asserts his belief that consciousness in the true sense of the word is present in all organisms having a centralized nervous system; furthermore, Haeckel invites us to the study of the 'sublime monism of Spinoza,' which, after all, is the very pantheism which Professor Shaler says has never held an important place in occidental philosophy.

It is not a far cry from Spinoza's self-existent universal substance, of which consciousness is only a mode, or Schelling's 'world soul' composed of the *union* of a positive and negative principle to Spencer's 'unknowable absolute.' In Spinoza and Schelling we have the pantheism of the East purified and shorn of its allegory and imagery. In Spencer we have the essentially modern, scientific arrangement of the data of our consciousness leading to conclusions only faintly adumbrated in the hazy speculations of *a priori* philosophers.

It has become the fashion lately in certain quarters to disparage the work of that splendid band of truth seekers who created modern science, not only by what they contributed in exact knowledge, but by the inspiration they afforded others and the impetus they gave to rational methods of research and speculation. Doubtless the generalizations of the great evolutionists will be modified by advancing knowledge, but I am confident that far into the future the pathway blazed by these men through the wilderness of ignorance, tradition and error will always be found leading towards truth, though possibly at times through tortuous ways. Hero worship and the weight of authority should not be permitted to stay the march of progress, but the cause of science is not best served by reading into the works of the great men of the past views which they would have been the first to repudiate.

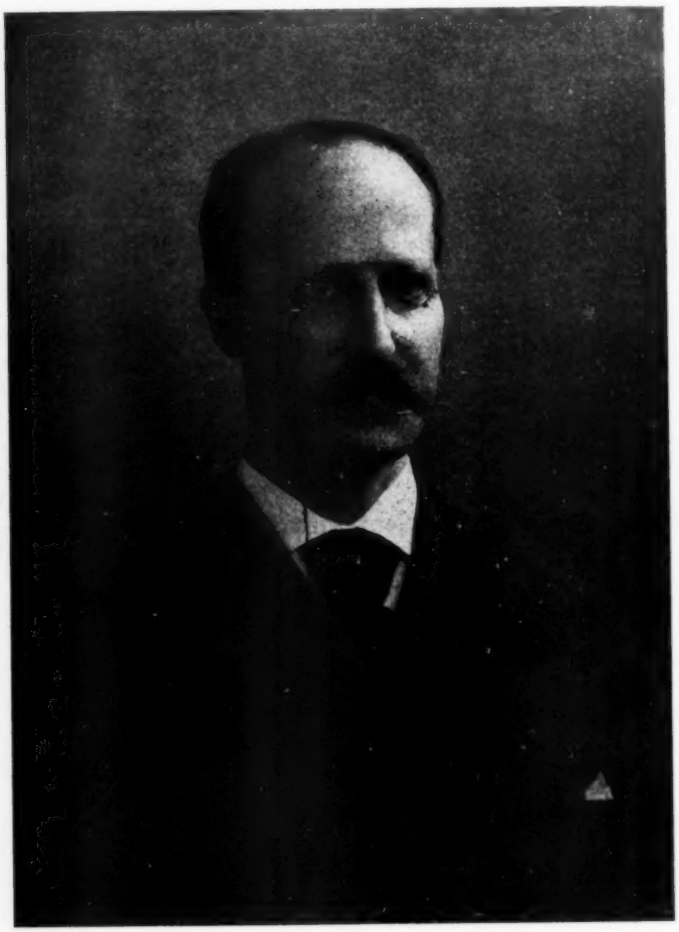
EUG. L. FISK.

NEW YORK.

SCIENTIFIC LITERATURE.

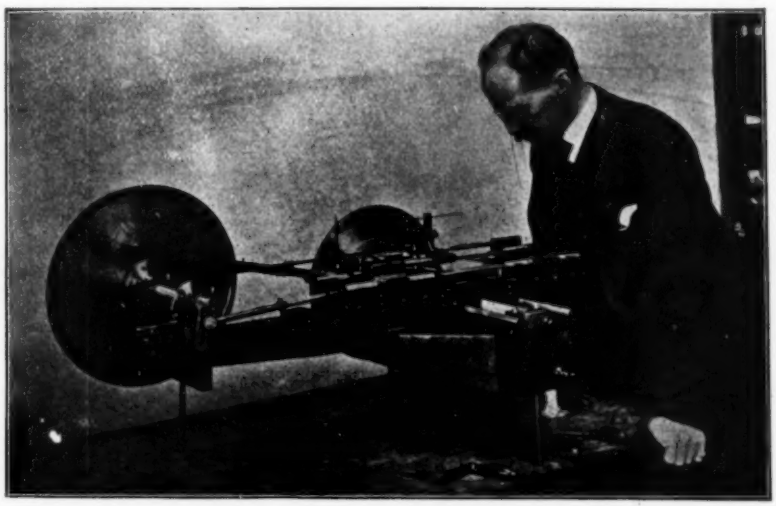
THE COLLECTED PAPERS OF ROWLAND AND FITZGERALD.

WE had occasion to note recently the severe losses of mathematical physics in the deaths of those to whom this most fundamental of the sciences is deeply indebted. Stokes in England and Gibbs in the United States were given time for a full life's work, but Rowland and FitzGerald were prematurely cut down, each at the age of about fifty years. The Johns Hopkins University has recently published the 'Physical Papers' of Rowland, edited



HENRY A. ROWLAND.

by a committee of which Professor Ames was the responsible member, and the Dublin University Press has published the 'Scientific Writings' of FitzGerald, edited by Dr. Joseph Larmor. These memorial volumes should be in the hands of many who are not physicists by profession. It is true that some of the papers contain mathematical formulas and technical statements not comprehensible to those without special training. But each volume also includes a number of masterly addresses revealing the progress of physical science, and the researches give an excellent introduction to the fundamental concepts of modern physics. They show science in the making in a way that is in many respects more attractive than a systematic treatise.



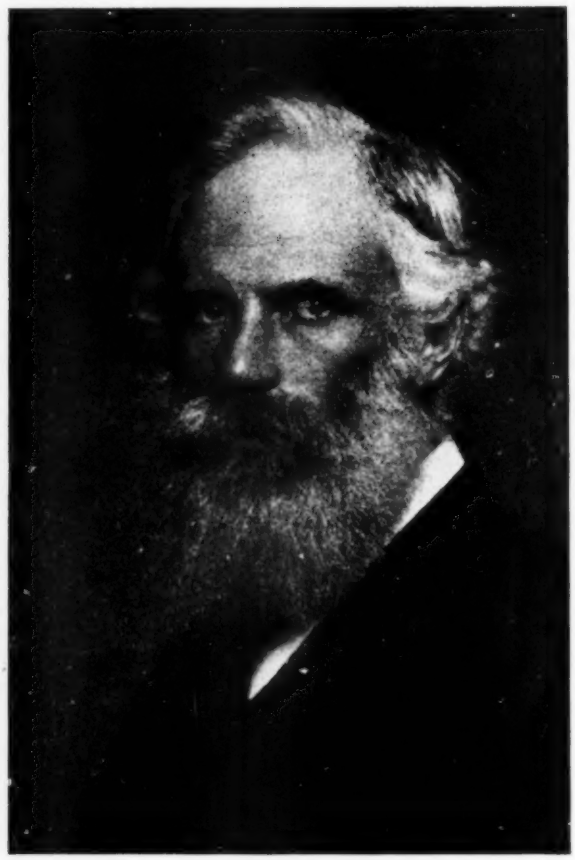
PROFESSOR ROWLAND'S DIVIDING ENGINE.

Rowland was by common consent the leading experimental physicist of his generation in this country. In one of his addresses he could only mention four American physicists of note—Franklin, Rumford, Henry and Mayer. Fundamental as the work of Franklin and Rumford proved to be in the history of science, it was in a way amateur in character, incidental to more absorbing activities; and Rumford's work can scarcely be credited to America. Henry's investigations were also fundamental, but they were in large measure fragmentary and unpublished. Mayer's ingenious experiments can scarcely be regarded as of great importance. Rowland may thus be regarded as the greatest experimental physicist that America has produced. He himself attributed our lack of productivity in pure physics to the counter attraction of invention and money-making; and in one of his addresses spoke very bitterly of the university professor who prostituted his chair to such uses. It is, however, not clear why a group of able inventors and experts should not lead to pure science as well as away from it. Rowland himself patented important inventions, as his application of alternating currents to rapid telegraphy, and acted as expert for engineering enterprises, as the electrical development at Niagara Falls.

Rowland's researches fall into three main groups—magnetism and electricity, heat and light—and in each

he made contributions of great importance. His early work on magnetic permeability attracted the attention of Maxwell, and his subsequent research on the magnetic effect of moving electrostatic charges was fully appreciated by Helmholtz, in whose laboratory it was carried out. Sixty-three papers on magnetism and electricity are included in the memorial volume. The research on the mechanical equivalent of heat was somewhat routine in character, determining with the most painstaking accuracy one of the most important physical constants. The photographic map of the normal solar spectrum and the determination of absolute wave-lengths were also the results of long-continued and careful detailed work, but they were made possible by the important work on screws, the construction of the famous dividing engine, and the great discovery of the use of a concave grating.

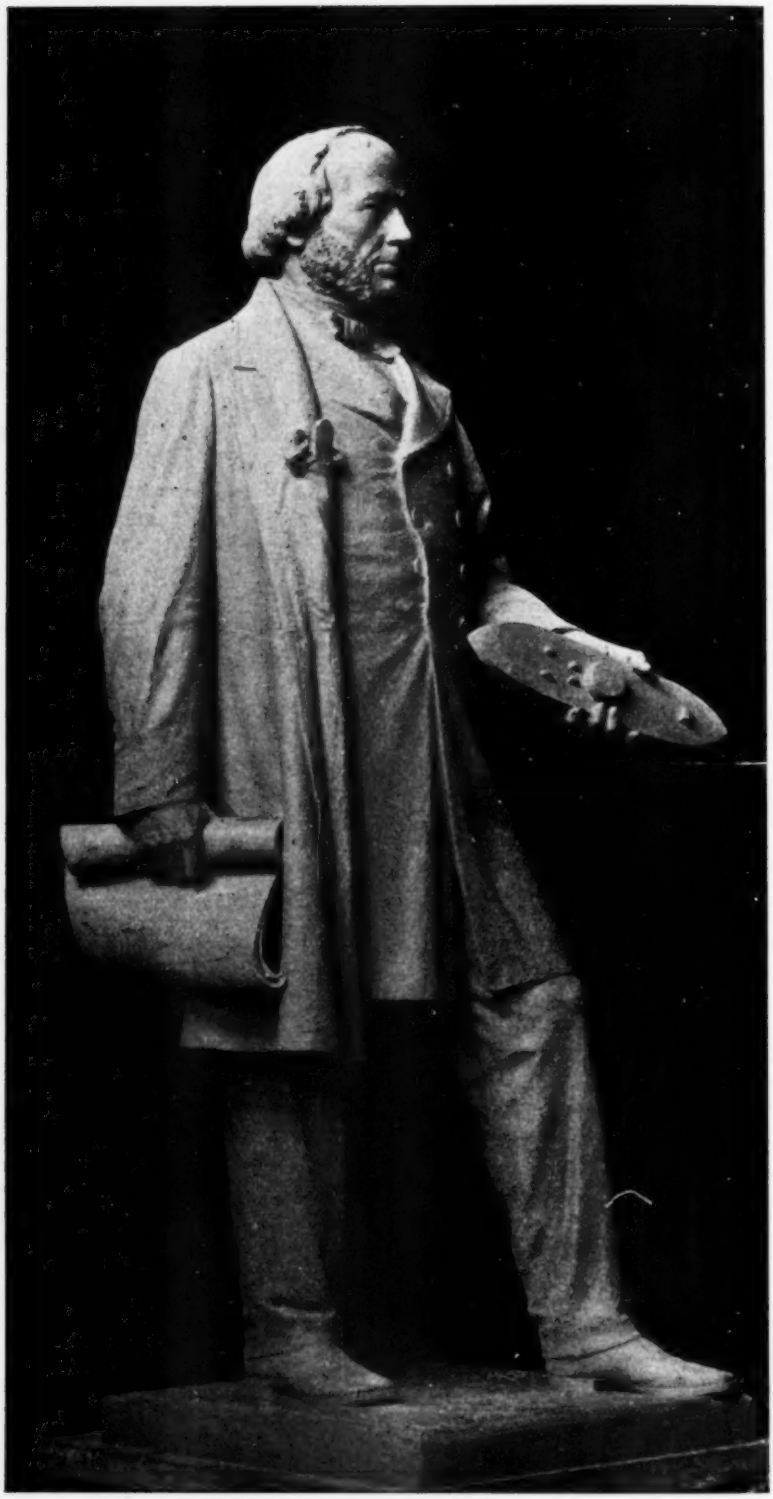
Rowland was fortunate in being called to the Johns Hopkins University at its organization, where for the first time in America the value of original research was fully appreciated and opportunity for research freely granted, and the university was fortunate and wise in calling a man who added so greatly to its reputation and influence. It is told of Rowland that when, in a



GEO. F. FITZGERALD.

suit over the value of his services, he was asked who was the greatest living physicist, he replied that he was. On being asked afterwards if this did not seem rather egotistical, he answered: 'I had to tell the truth, I was testifying under oath.' His personality was attractive to those who knew him well and understood his supreme absorption in his own work. To others he doubtless seemed self-centered, somewhat unsympathetic and undemonstrative. FitzGerald appears to have had exactly the opposite characteristics. Physiognomy is extremely illusive, but the portraits here given seem to indicate the individualities of the two men. FitzGerald was unselfish and self-sacrificing almost to a fault. Dr. Mendenhall tells us in his commemorative address that Rowland did not know even approximately how many students he had, and on being asked what he would do with them, replied: 'Do with them?—I shall neglect them.' But he adds: 'To be neglected by Rowland was often, indeed, more stimulating and inspiring than the closest personal supervision of men lacking his genius and magnetic fervor.' FitzGerald sacrificed his research work to teaching, to administration and to helping others; he was always ready to give his ideas to students and to his friends. He took no interest in questions of priority and scientific credit. Rowland spoke of 'professors degrading their chairs by the pursuit of applied science.' FitzGerald said that it was a small matter whether the human race got to know about the ether now or fifty years hence, but that it was a vital matter that present scientific ignorance should not continue for a generation.

FitzGerald tended to devote himself more and more to human affairs, giving much time to the Irish Education Board and visiting this country to observe our schools; but the memorial volume containing his collected papers shows that he did contribute greatly to our knowledge of the ether. He was almost the first to appreciate fully Maxwell's work and to carry it forward, his memoir 'On the Electromagnetism of the Reflection and Refraction of Light,' presented before the Royal Society in 1888, being accepted as a classic. Many of his other papers contain important contributions and suggestions, and the addresses should be of interest to all those who are able to appreciate the great forward advance in our views on the nature of electricity and the constitution of matter. It may be noted as of incidental interest that FitzGerald did not go to school as a boy; his father was an eminent bishop, and his mother a sister of the mathematical physicist, Professor Johnstone Stoney.



JOHN ERICSSON.

THE PROGRESS OF SCIENCE.

JOHN ERICSSON.

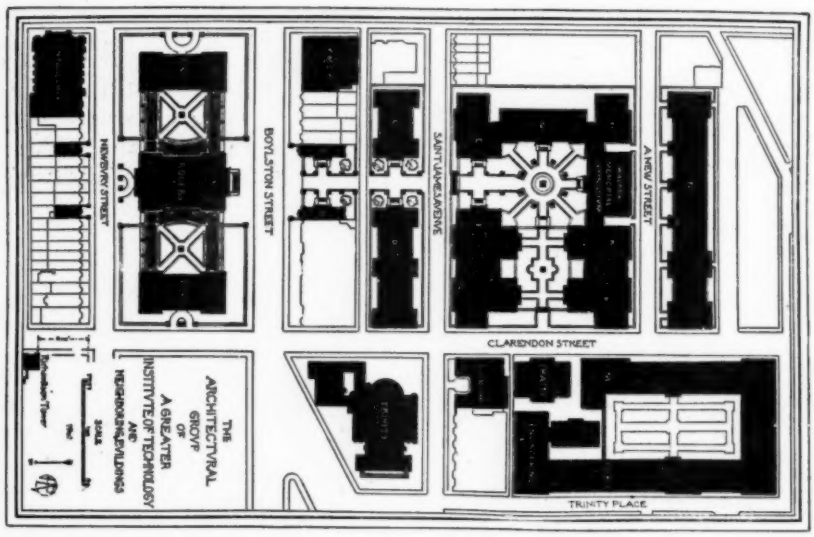
THE centenary of the birth of John Ericsson was celebrated on August 1 by the unveiling of a statue in the Battery, New York City. A bronze statue by Mr. Jonathan S. Hartley had for ten years stood near the Custom House, but the sculptor wished to improve it, and at his own expense made a new statue, in which the same metal was used. By the courtesy of Mr. Hartley, we reproduce a photograph of the model as it stood in his studio. The ceremonies connected with the unveiling of the statue were elaborate, the army and navy being represented, and the Swedish-American Societies taking a prominent part. Mayor Low accepted the statue for the city and Colonel W. C. Church, author of the life of Ericsson, made an address. Both speakers naturally referred to the building of the *Monitor* and its destruction of the confederate ironclad *Merrimac* on March 9, 1862. It will be remembered that on the preceding day the *Merrimac* had destroyed the *Cumberland* and the *Congress*, and was about to disperse the rest of the government's wooden fleet, when the *Monitor*, which had been built by Ericsson in New York in one hundred days, altered the course of events and perhaps the whole result of the civil war, for if the federal government had had no fleet, European intervention would have been likely. Shortly after Ericsson came to the United States in 1839, he built the *Princeton* for the United States Navy, the first vessel having the propelling machinery below the water line, and this vessel set the model for all subsequent naval construction. Ericsson is consequently remembered largely in connection with the development of ships of war, to which he made the most important contributions. His other great scientific inventions, however, should not be forgotten, especially the screw propeller, which while originally designed for warships has become one of the greatest factors in steam navigation. Europe was long sceptical as to the possibility of the propeller, it being claimed that a vessel would not steer when power was applied at the stern, even after many vessels were being successfully navigated in the United States.

Ericsson began his inventions when a boy in Sweden, and at the age of twenty-two constructed a condensing flame engine of ten horse power. In 1828, when twenty-five years of age, he made the first application to navigation of the principle of condensing steam and returning water to the boiler. In 1829, when twenty-six years old, he built the steam carriage, *Novelty*, which competed with George Stevenson's for the Liverpool and Manchester railway prize. It surpassed all competitors, including Stevenson's *Rocket*, in lightness and speed, attaining the remarkable speed of thirty miles an hour. At this period and a little later he made numerous important inventions, including the tubular steam boiler with artificial draught and the caloric heat engine. He also made some important instruments for scientific work, including the self-registering deep-sea lead, a pyrometer and a hydrostatic gauge. Ericsson must be regarded as one of those who made the nineteenth century before all else an era of the applications of science.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

A MOVEMENT is now in progress to establish a great school of technology in connection with the University of London. Through the efforts of Lord Rosebury, chancellor of the university, a sum of $2,500,000 has been subscribed for buildings and land. The London County Council has agreed to contribute $100,000 a year for maintenance on condition that the government and other municipalities take part in the movement. In all the discussions in regard to the establishment of this school of technology, reference has been made to the fact that Germany and America are in advance of Great Britain in their provision for technical education, and of all our schools, the Massachusetts Institute of Technology is the most noteworthy.

The institute is at present seriously considering the desirability of obtaining a new site. The land on which its buildings now stand having become part of the business quarter of the city, land adequate for the needs of the institute could only be purchased at great expense. The institute has recently obtained powers from the legislature to sell its present site should it wish to do so, it having originally been a condition that it forever be preserved from sale. This permission was not obtained without a considerable amount of opposition, and the parallel bill on behalf of the Society of Natural History has not been passed. There still appears, however, to be some opposition to the change. Mr. Henry A. Phillips contributed to the last number of *The Technology Review* a plan for developing the institute on its present site, as shown in the accompanying figure. The buildings now occupied by the institute are the Rogers, the Walker, the Engineering and the Pierce buildings. It is estimated that the land required for the development here sketched would be $1,800,000, according to the assessed valuation, whereas the removal of the institute would require the sacrifice of buildings worth perhaps $1,000,000.



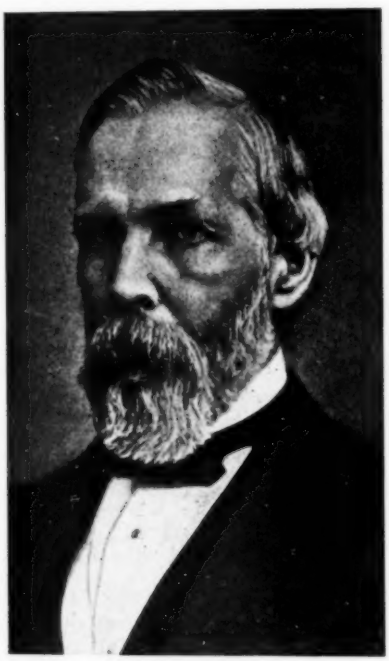
PROPOSED PLAN FOR THE ENLARGEMENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

The Institute of Technology has this year made on its educational side an important advance in establishing a

graduate school of engineering research including two research laboratories, one for physical chemistry under the charge of Professor A. A. Noyes and one for sanitary engineering under the charge of Professor Wm. T. Sedgwick. The former is to occupy one of the new buildings now being erected beyond the Pierce building, and will consist mainly of a series of small laboratories, with special rooms for weighing, photography, glass-blowing, pure water distillation, etc. There will be next year nine or ten research assistants and associates working under the direction of the professors of the institute, and every facility will be given to advanced students wishing to carry on research work. The Sanitary Research Laboratory and Sewage Experiment Station has leased a building on the line of the largest main sewer, in which have been fitted up laboratories for chemical and bacteriological work, including a tank and filter house.

The institute has recently lost by death two of the original members of its faculty, whose portraits are here given. Professor John B. Henck was professor of civil engineering from 1865 to 1881. During this period he devoted himself largely to the work of teaching, but at this time and previously he also carried forward engineering works, the most important probably being the filling in and improvement of the Back Bay district of Boston. His 'Field Book for Railway Engineers,' published in 1854, and subsequently revised, passing through many editions, is a standard work. After retiring from his chair at the institute, Professor Henck settled in California and spent his life in retirement, dying early in the present year at the age of eighty-eight years. Professor John D. Runkle was professor of mathematics at the institute from 1865 until last year, when he was made professor emeritus. During this long period he was closely identified with the development of the institute, being always one of the leading members of the faculty and for a time presi-

JOHN D. RUNKLE.



JOHN B. HENCK.

dent. Before he occupied this chair, he was engaged in the work of the Nautical Almanac, and founded *The Mathematical Monthly* in 1859. He took a prominent part in introducing manual training, not only in the institute, but also in the schools of the country.

SUMMER LABORATORIES AND SCHOOLS.

EDUCATION in America owes much to Louis Agassiz, and one of its greatest debts is the summer school of natural history established by him on the island of Penikese in 1873, the year before his death. The school did not long survive its founder, but it may be regarded as the beginning of the summer schools and laboratories which now play such an important part in the educational and scientific life of the country. Our college sessions have followed the precedent of Oxford and Cambridge in allowing long summer holidays. Formerly many of the students worked on the farm or otherwise during the summer months, and the heat of the season seemed to make natural a long vacation both in schools and colleges. But it seems to be no longer the case that college students commonly spend the long vacation in a profitable manner, and it has been discovered that teachers have in their holidays great opportunity for study and culture. The conditions have led to a complex and rather heterogeneous provision for education and research during the summer months. We have the Chautauqua movement, based mainly on religious interests, in which many denominations under one name or another have taken part. The school on Martha's Vineyard represented an extension of the teachers' institute, leading the way to the university summer schools. There have been schools for agriculture, for modern languages, for philosophy and of other kinds. But the two movements now the most wide-reaching and likely to be the most permanent are the laboratories of biology and the summer sessions of the universities.

BUILDINGS OF THE MARINE BIOLOGICAL LABORATORY, WOODS HOLE.

There are obvious reasons for pursuing the study of botany and zoology

during the summer season and by the seaside or some inland water. Thus can the needed material be obtained at the right time, and the collecting and exploring unite in the best possible manner study with healthful recreation. The general spirit of the laboratories is excellent; research is carried forward side by side with instruction, so that the dividing line is almost obliterated; there is a friendly spirit of cooperation and rivalry; things are known at first hand rather than darkly through books and lectures; the standard of living is simple; the follies and worse not uncommon in the colleges are lacking to a noticeable degree.

The Marine Biological Laboratory at Woods Hole may be regarded as the lineal descendant of Agassiz's school at Penikese, of which it has well maintained the traditions. The equipment has always been modest, as is shown by the accompanying photograph of the buildings, and perhaps this has not been a serious disadvantage. It is, however, hoped that sooner or later a fireproof building, which may be kept open in winter as in summer, will be erected. There are each year at Woods Hole between fifty and one hundred investigators carrying on original research, and about an equal number of students, many of whom become investigators. The Carnegie Institution has wisely decided not to acquire the laboratory, but is supporting it by contributing $10,000 for twenty tables, and the laboratory is thus on a secure financial basis without loss of the independence and spirit of cooperation which have accomplished so much in the past. While the Woods Hole laboratory remains our chief center of biological research, rivaled only by Naples, other laboratories have been established along the Atlantic and Pacific coasts, at the Bahamas and on inland waters. Expeditions and camps of a temporary character should be mentioned in connection with the summer schools of natural history; practically all the geologists of the country are now in the field, and in many cases the parties consist of expert investigators accompanied by those who assist and learn.

The summer schools of the universities have not yet found their permanent basis, but there is no question as to the direction of their development and of the importance of the movement. A summer school once established is seldom abandoned and nearly always shows an increase in size and an improvement in quality from year to year. There are this summer over a thousand students at Harvard and at Columbia, and nearly twice as many at Tennessee. The students are largely teachers, but there are others of mature age, who wish to improve themselves. Then there are some regular students of the institutions—on the one hand, those so much interested in their work that they do not wish to lose the summer and, on the other hand, a few who need to 'make up conditions.' The instructing staff is also heterogeneous, there being usually some eminent lecturers and a good many young assistants. Chicago set the example of continuing its terms through the year, though in attempting to adjust its summer quarter to the needs of teachers, it has abandoned its original plan. We expect to see the university year ultimately divided into four quarters, with perhaps two weeks' vacation between each. The work of the summer term will be as 'regular' as any other, but as there will be fewer students an opportunity will be afforded to provide a special summer school for teachers. There are over 300,000 teachers in the country. It would be well if all schools would pay them a certain salary and in addition provide for their attendance at a summer school.

SCIENTIFIC ITEMS.

WE regret to record the death of Professor W. C. Knight, professor of

geology and mining engineering in the University of Wyoming, and of Mr. William Earl Dodge, a merchant, known for his interest in educational and scientific institutions.

THE University of London has conferred honorary degrees for the first time, the degrees of Doctor of Laws being given to the Prince of Wales, of Doctor of Music to the Princess of Wales and of Doctor of Science to Lord Kelvin and Lord Lister. It is said that the degree was offered to Mr. Herbert Spencer, but declined by him.—The Honorable Arthur Balfour, the British premier, has accepted the presidency of the British Association for the meeting to be held in Cambridge in 1904.—Sir W. Ramsay has been elected president of the Society of Chemical Industry. The society has decided to meet next year in New York City.

DR. W J MCGEE has recently resigned his position in the Bureau of American Ethnology to take charge of the Department of Anthropology and Ethnology of the Louisiana Purchase Exposition.—Mr. Bailey Willis has accepted the position of leader of the Carnegie Geological Expedition to China, which has as its object the investigation of the Cambrian of that country.

THE Desert Laboratory, being erected by an appropriation from the Carnegie Institution at Tucson, Arizona, is expected to be ready for occupancy on September 1, when Dr. W. A. Cannon, now assistant in the laboratory of the New York Botanical Garden, will become resident investigator.

THE sixth International Congress of Psychology, which was to have met in Rome in the autumn of 1904, will be postponed to the spring of 1905 to avoid conflict with the sixth International Congress of Physiology which meets at Brussels in the autumn of 1904.

MR. CARNEGIE'S gift of $1,000,000 to the four national engineering societies and the Engineers' Club for a building has been accepted at a meeting of the representatives of the five organizations, and plans have been made for a joint committee consisting of three members from each organization. This committee will prepare plans for a building to be erected on Thirty-ninth Street. Efforts are being made to secure funds for the purchase of the land, and a number of subscriptions have been received by the American Institute of Electrical Engineers, including $5,000 from Dr. Elihu Thomson and the Westinghouse Electrical Company, $2,000 from Mr. Frank S. Sprague and $1,000 with a contingent $1,500 from Mr. J. G. White.

CHAPTERS of the university scientific society of the Sigma Xi have recently been established at the Chicago and Michigan Universities. Chapters of this society are now maintained at the following universities: Cornell, V. A. Moore, president; Union, O. H. Landreth, president; Kansas, F. H. Snow, president; Rensselaer, W. P. Mason, president; Yale, J. P. Tracy, president; Brown, W. W. Bailey, president; Nebraska, L. Bruner, president; Minnesota, J. J. Flather, president; Iowa, T. H. McBride, president; Ohio, W. R. Lazenby, president; Pennsylvania, E. F. Smith, president; Stanford, V. L. Kellogg, president; California, C. L. Cory, president; Columbia, J. F. Kemp, president; Chicago, H. H. Donaldson, president; Michigan, J. P. McMurrich, president.